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The Programmatic Approach in Environmental Governance

The Dutch and Flemish Programmatic Approach to Nitrogen as cases for the Programmatic Approach in Environmental Governance

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De programmatische aanpak in milieubeleid:

De Nederlandse en Vlaamse Programmatische Aanpak Stikstof als casussen voor de programmatische aanpak in milieubeleid

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Abstract

The Programmatic Approach is used as environmental governance tool in situations where environmental pressures must be balanced with Nature conservation within a limited Environmental Utilization Space. The Dutch and Flemish Programmatic Approach to Nitrogen (PAN), both implemented to deal with Nitrogen Deposition on vulnerable Natura 2000 habitats, are studied as example cases to gain insights into their strengths and weaknesses and propose possible improvements for a Programmatic Approach in general. The analysis of both cases uses the Environmental Utilization Space model (EUS) as theoretical framework. Within the EUS model, the focus in the case-studies is on three research aspects: (1) uncertainties, (2) Monitor-Learn-Adaptation (MLA)-principle, and (3) trade-off influences. In total, 39 research documents have been studied using deductive coding with Atlas Ti. After analysis of the observations, the preliminary findings have been studied in more detail by conducting 5 expert interviews.

The research shows that bot the Dutch and Flemish PAN failed to provide a solution for the problem of nitrogen deposition. A major weakness in the Dutch and Flemish PAN is the dependency on voluntary cooperation by farmers to invest in emission reducing source measures, and cooperation of landowners to support habitat recovery measures. The lack of back-up source measures to adjust the PAN as needed, hampered proper application of the Monitor-Learn-Adapt principle which is a key principle in a PA. Another weakness in the Dutch and Flemish PAN was the poor level of ecological monitoring. Clear ecological reference points and indicators to monitor ecological effects still had to be established, and the application of the MLA-principle looked good on paper but was not effective in practice. The trade-off of socio-economic interests and nature conservation by permitting authorities is supported differently in the Dutch and Flemish PAN. The Dutch PAN supports the permitting authorities by means of the AERIUS monitoring module which reduces the permitting to ND bookkeeping. This is clear but oversimplifying the ND problem and the ecological perspective. A more sophisticated but intensive process is applied in Flemish PAN. The Appropriate Assessment of permit requests, and the use of Search Zones to optimally designate conservation objectives in habitats, allow to incorporate local circumstances and knowledge. This supports the permitting authorities during the balancing act. A strength in the Dutch and Flemish PAN is that much effort is put in the development of ecological monitoring indicators and the efforts to improve ND calculations and models. The main findings that follow from this research is that, in order to work effectively, a Programmatic Approach should (1) avoid dependency on voluntary cooperation, (2) have back-up measures readily available to adapt approach to changing circumstances and the results of monitoring, and (3) leave flexibility for permitting authorities to incorporate local circumstances and knowledge. A Programmatic Approach however can not materialize without serious fundamental political choices to bring the levels of environmental pressures back within the EUS boundaries within a reasonable time.

Samenvatting

De programmatische aanpak wordt in milieubeleid toegepast om milieudrukken te balanceren met natuurbehoud binnen de grenzen van de milieugebruiksruimte. De Nederlandse en Vlaamse Programmatische Aanpak Stikstof (PAS), beiden geïmplementeerd om stikstofdepositie op gevoelige Natura 2000 habitats tegen te gaan, zijn als voorbeeld-casussen bestudeerd om inzicht te verkrijgen in hun sterke en zwakke elementen en daarmee voorstellen te doen voor mogelijk verbeteringen van de programmatische aanpak in het algemeen. De analyse in de casussen maakt gebruik van het theoretisch kader “milieugebruiksruimte” (Environmental Utilization Space (EUS)). Binnen het EUS-model is de focus gelegd op drie research aspecten: (1) onzekerheden, (2) Monitor-Learn-Adapt-principe en (3) afwegingensinvloeden. In totaal zijn 39 onderzoeks- documenten geanalyseerd door middel van deductief coderen met het Atlas Ti softwarepakket. Na analyse van de observaties zijn de voorlopig bevindingen meer in detail geanalyseerd door het uitvoeren van 5 expert-interviews.

Het onderzoek toont aan dat de Nederlandse noch de Vlaamse PAS een oplossing kan brengen voor het stikstofdepositieprobleem. Een belangrijk zwak element in de Nederlandse en Vlaamse PAS is de afhankelijkheid van vrijwillige medewerking door landbouwers om emissiereductie-bronmaatregelen toe te passen, en van landeigenaren om herstelmaatregelen te ondersteunen. Het gebrek aan back-up bronmaatregelen om de PAS bij te sturen blokkeerde de toepassingen van het Monitor-Learn-Adaptation-principe terwijl dit een sleutel-principe is binnen de programmatische aanpak. Een ander zwak element in de Nederlandse en Vlaamse PAS was de gebrekkige ecologische monitoring. Een ecologisch nul-referentiepunt, alsook indicatoren om ecologische effecten te kunnen monitoren, moesten bij de start van de PAS nog vastgesteld of ontwikkeld worden. De toepassing van het MLA-principe bij ecologische monitoring klopte op papier maar was niet effectief in de praktijk. De afweging door vergunningverleners van socio-economische belangen en natuurbehoud werd bij de Nederlandse en Vlaamse PAS verschillend opgevat. De Nederlandse PAS ondersteunt de vergunningverlening met de AERIUS monitoring module waardoor de vergunningverlening verworden is tot stikstofdepositie-boekhouding. Dit is transparant maar over-simplificeert het stikstofdepositieprobleem en het ecologisch perspectief. In de Vlaamse PAS wordt een meer gesofisticeerd maar ook intensiever proces gevolgd. De passende beoordeling per

vergunningaanvraag, in combinatie met het gebruik van zoekzones om lokale instandhoudingsdoelstellingen optimaal in de beschermingszones te plaatsen, zorgen voor het gebruik van lokale kennis en anticiperen op lokale omstandigheden. Dit helpt de vergunningverleners met het vinden van de balans. Sterke elementen in de Nederlandse en Vlaamse PAS zijn de ontwikkelingen op het gebied van ecologische monitoring met indicatoren en de verbeteringen van de stikstofdepositieberekeningen en -modellen. De belangrijkste bevindingen die uit deze studie volgen, zijn dat in een programmatische aanpak (1) niet afhankelijk mag zijn van vrijwillige medewerking, (2) back-up maatregelen achter de hand moet hebben om de aanpak te kunnen bijsturen naar gelang de omstandigheden en monitoring-resultaten, en (3) flexibiliteit moet hebben om vergunningverleners de lokale kennis en omstandigheden te kunnen toepassen. Een programmatische aanpak in milieubeleid kan echter geen resultaat opleveren zonder dat eerst serieuze fundamentele politieke keuzes gemaakt worden om de milieudrukken binnen de grenzen van de milieugebruiksruimte te brengen binnen een redelijke termijn.

1. Introduction

The balance between nature conservation and socio-economic interests is a core research field in environmental sciences. The Programmatic Approach can be a valuable governance instrument to achieve and keep this balance, for example in the in the Air Quality Directive, Nitrate Directive and the Water Framework Directive, and is planned to be an important policy instrument in the Dutch Environmental and Planning Act (Folkert et al., 2014; Squintani, Plambeck, & Van Rijswick, 2017)

The literature on PA's as Environmental Governance instrument shows that PA's leave space for flexibility for the competent authorities to balance environmental, spatial, and economic interests and choice in measures (Van den Broek & Boeve, 2012). Squintani and Van Rijswick describe the feature that in typical PA's the authorization of individual projects is "delinked" from the applicable environmental quality standard under the condition that the program with individual projects as a total ensures compliance with the standard. In these PA's the program is assessed as a whole and not every individual project. This gives competent authorities more freedom in the way environmental goals are achieved and it is in line with the desired deregulation (Kegge & Drahmann, 2020; Squintani & van Rijswick, 2016). From juridical perspective, the Advocate General of the European Court of Justice states the following about the Programmatic Approach: "an assessment at such a level of generality makes it possible to examine better the cumulative effects of various projects" (ECLI_EU_C_2018_882 PAS ruling cases C293_17 and C294_17 par 97). In the same statement however is emphasized that all requirements of Article 6(3) regarding the appropriate assessment of the Habitats Directive must be met.

Another characteristic of PA's is that the balancing occurs around a so-called *Environmental Utilization Space (EUS*). The EUS can be considered as the available space, for example the amount of emissions, physical space, or quota of a certain kind, that is available for activities without affecting the environment (de Graaf, Platjouw, & Tolsma, 2018). According to De Graaf et al., the concept of utilization space is a key characteristic of PA's for the protection of ecosystems, but they also argue that the success of the design and implementation of such Environmental Programs heavily depends on the discretion of public authorities in the trade-off between environmental measures and economic development (de Graaf et al., 2018). The flexibility that PA's have regarding balancing economic and environmental interest comes with the "flexibility versus legal certainty"- dilemma which can cause legal stability problems for PA's (Squintani & van Rijswick, 2016).

Further, the "Monitor, learn & adapt (MLA)- principle" is very important for the effectiveness of PA's as environmental governance tool because, since socio-ecological systems often have many unknowns and sometimes large scientific uncertainties (Boeve & Groothuijse, 2014). Proper monitoring and adaptions can reduce the uncertainties and improve the PA's effectiveness. Further, the Programmatic Approach can be an important tool for environmental governance that potentially avoids a deadlock of administrative and social burden (de Graaf et al., 2018; Squintani & Zijlmans, 2019; Van der Feltz, 2015)

In summary, we can consider the Programmatic Approach an interesting instrument that deserves a closer look. Therefore, this thesis aims to study two empirical cases in which the Programmatic Applied was applied: The Dutch and Flemish Programmatic Approach to Nitrogen (PAN). Both PANs were developed to reduce the effects of reactive Nitrogen Deposition on vulnerable Natura 2000 habitats.

Scientific and societal relevance of the Dutch and Flemish PAN cases

The deposition of airborne reactive Nitrogen emissions is a worldwide environmental problem, particularly in densely populated areas with high traffic and industry intensity, and a large livestock. Nitrogen Deposition (ND) is mainly caused by fossil fuel combustion processes (NOx, especially N2O and NO), and livestock farming (NH3) (Bobbink et al., 2012). Once airborne, reactive nitrogen (Nr) particles can, depending on weather conditions and the type of reactive nitrogen, travel over relatively long distances or deposit within only a few kilometers distance (Bobbink, 2021, pp. 20, 21). Beside health problems caused by Nr particles (RIVM, 2018, 2020), cumulative abundant Nitrogen Deposition above a certain Critical Load[1] has disturbing effects on the balance of nitrogen compounds in the soil which results in eutrophication, acidification, and changes in the composition and diversity of the ecosystem's vegetation. With the change in vegetation composition, the species richness of ecosystems declines and therefore ND is a threat to the biodiversity (Stevens et al., 2010) and a major reason for

[1] Critical Load is defined as "the limit above which there is a risk that the quality of the habitat type is significantly damaged as the result of acidification or eutrophication from atmospheric nitrogen deposition. (Dobben, Bobbink, & Bal, 2014).

not meeting the nature conservation obligations as stipulated in the Habitat Directive HD (Bobbink et al., 2012; Van den Burg, 2019).

Data from the Dutch Ministry of Economic Affairs and the Ministry of Agriculture and the Environment in 2014 show that in 124 of the 164 Natura 2000 area's the ND levels are a threat to the survival of its habitats. Depending on the habitat-type and its sensitivity to nitrogen, the critical load varies between roughly 500 and 1400 mol/ha/yr (Van den burg et al, 2021, p. 23) while the average ND in The Netherlands in 2013 was 1655 mol/ha (Velders et al., 2014, p. 75). The levels decreased since 1980 with approximately 30% but the ND pressure is still 2 to 3 times the Critical Load in many cases (Folkert et al., 2014, p. 29). Livestock farming is the largest contributor to Nitrogen deposition with 40%. An important consideration is that ammonia emitted by cattle farms is deposited within a relatively short distance and since many farms are close to Natura 2000 areas, cattle farming is by far responsible for the exceedance of the critical load on Natura 2000 habitats. A large portion of the Dutch ND originates from abroad (30%). Transportation, building construction, industry and households contribute with mainly emission of NOx (Velders et al., 2014). In Flanders, a region of the EU Member state Belgium, the ND levels are similar to the Dutch situation. An average amount of 24,6 kg N/ha (1750 mol/ha) was deposited in 2017 and the figures provided by the Vlaamse milieumaatschappij (VMM) show a stagnation in the decrease in ND since 1990. The contribution of ammonia to the ND remained almost constant with 61% in 1990 and 59% in 2017. Agriculture contributes for 41% to the ND in Flanders, transportation for 9% and 46% originates from abroad (Vlaamse Milieumaatschappij, 2019).

The Dutch and Flemish PAN aimed to stop further deterioration of Natura 2000 habitats and, in the long term, decrease the ND levels below the Critical Load so the Natura 2000 conservation objectives could be met (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017; Schauvliege, 2016b, p. 2). At the same time, the Program foresees in permitting new economic activities in a controlled way. The Environmental Utilization Space (EUS), in the Dutch PAN referred to as "Room for Nitrogen Deposition" (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 7), is created by source measures that reduce nitrogen emission levels on the one hand and ecological recovery measures for Natura 2000 habitats on the other hand. The Flemish PAN also prescribes "source measures" to reduce ammonia emissions and "recovery measures" to help habitats recover from the effects of decennia of ND (Schauvliege, 2017). The source measures and recovery measures created the basis for unlocking the permitting system for socio-economic development (Schauvliege, 2016b, p. 3)

The Dutch PAN gained much attention because it was a remarkable instrument that could unlock a permitting system for new activities that would create new ND room while on many habitats the Critical Load for ND was already exceeded. This made the Dutch PAN controversial and subject to many law cases. The contents of the PAN was heavily debated among politicians, scientists, NGO's and representatives from farmers and industry. On May 29th 2019, the Dutch Council of State ruled that the PAN was in conflict with the Habitat Directive [2] and the PAN was annulled (Afdeling Bestuursrechtspraak van de Raad van State (ABRvS), 2019). In Flanders, the ruling by the Council for Permit Disputes (Raad voor vergunningenbetwistingen) on 25th of February 2021 about the extension of a chicken farm[3], ended the Flemish PAN as basis for permitting new ND causing activities (Raad voor Vergunningenbetwistingen, 2021).

Notwithstanding the annulment of the Dutch and Flemish PAN by court rulings, these cases are worth studying in detail and learn from the experiences. ND is an important environmental pressure that needs an urgent response to avoid irreversible damage to unique habitats and loss of biodiversity. But the ND problem in The Netherlands and Flanders is also complex because it involves many stakeholders and touches upon the characteristics of society and the way of living. The population density is high, the busy traffic is dominated by fossil fuel combusting vehicles and The Netherlands and Flanders have a tradition of industry and intensive farming. Hence, optimization of an environmental governance instrument that balances these characteristics with conservation of habitats seems more than welcome.

[2] The Administrative Jurisdiction Division of the Dutch Council of State concluded that the PAN did not meet the requirements set by the CJEU that, even though a programmatic approach such as the PAN is not principally in contravention of the Habitat Directive, the associated appropriate assessment should be scientifically sound and it should be beyond reasonable doubt that ecological values would not be impaired.

[3] The permit for a chicken farm extension was legally challenged by two environmental organizations and annulled because the extra ND that would be caused by the extension of the chicken farm was considered an activity with significant impact on a vulnerable Natura 2000 area. Therefore, an Appropriate Assessment should have been conducted to according to the Habitat Directive. Instead, the permit application had referred to the significance threshold levels that were mentioned in the Flemish PAN and below which an Appropriate Assessment was not needed.

Reducing the ND pressure without stopping socio-economic development seems to be challenging, if not impossible. Besides, ND is not the only environmental pressure that threatens our limited and vulnerable remaining unique habitats. Fragmentation, drought, chemical pollution, and climate change are all examples of pressures of which our nature can bear only a limited amount before critical boundaries are exceeded and irreversible damage is caused. Balancing environmental pressures within these boundaries is a key study field with Environmental Sciences and fits within the planetary boundaries concept that was proposed by Rockstrom et al. (see figure 1). Rockstrom et al. identified 9 planetary boundaries in which humanity can operate safely and that should be respected in order to avoid "abrupt global environmental change" (Rockström et al., 2009, p. 31).

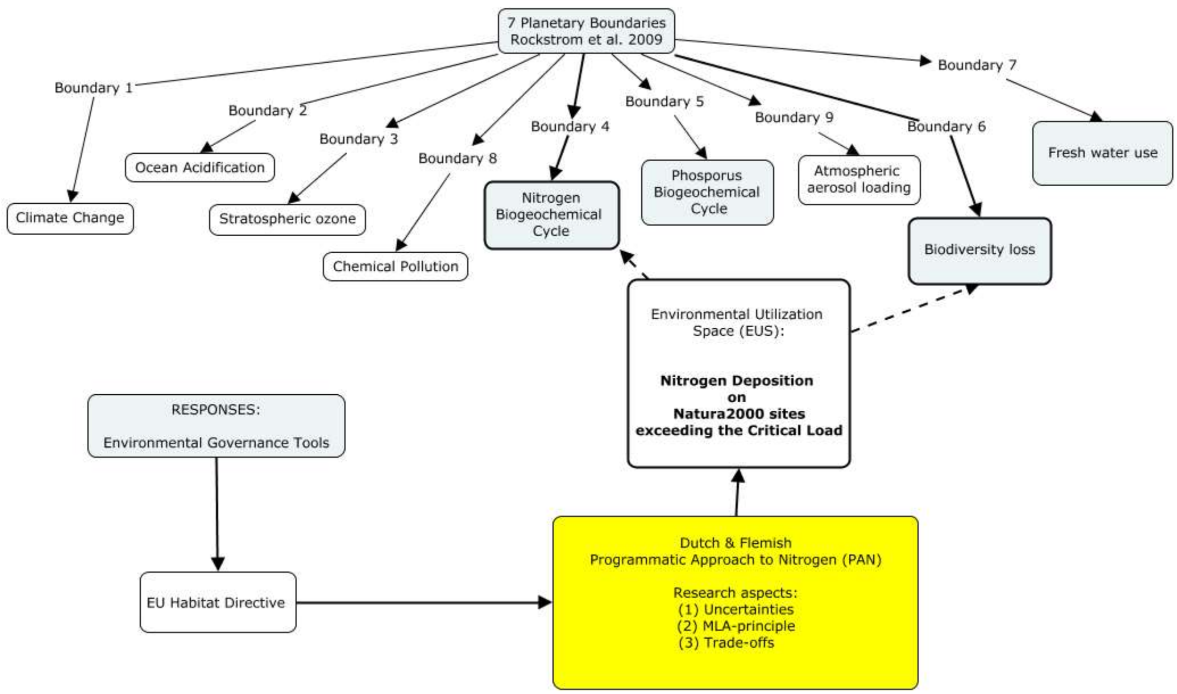

Figure 1: The place of this research within the conceptual model of the Planetary Boundaries*. The ND problem is linked to at least two boundaries: the boundaries for biodiversity loss and the Nitrogen biogeochemical cycle. The Dutch and Flemish PAN are based on the EU Habitat Directive obligations and aim to bring back the ND levels below the Critical Load. This research (yellow block) focuses on the research aspects "Uncertainties", "Monitor-Learn-Adaptation-principle" and "trade-offs between socio-economic interests and nature conservation".*

Research objective and questions

A structured analysis of the Dutch and Flemish PAN cases is proposed to study three research aspects that are believed to shape the effectiveness of Programmatic Approaches: (1) Uncertainties, (2) the Monitoring-Learn-Adaptation-principle, and (3) Trade-off influences. With this study we aim to:

(a) determine how the design of a Programmatic Approach as instrument for environmental governance can be optimized

(b) analyze the Dutch and Flemish PAN cases and identify the strengths and weaknesses regarding their effectiveness to deal with Nitrogen Deposition in Natura 2000 sites.

Some attention will be given to the comparison of the Dutch and Flemish PAN but the main focus is on finding strengths and weaknesses in both cases that will be used to reflect on the design of a programmatic approach as an environmental governance tool.

From the study objective we formulated the following main research question:

What strengths and weaknesses in the Dutch and Flemish PAN determine their success/failure regarding its effectiveness as Programmatic Approach to reduce ND in Natura 2000 sites and how do these empirical findings relate to the Programmatic Approach as environmental governance instrument?

The answer to this question will be based on the findings in the two case studies. For the case studies we listed 5 sub questions that integrate the 3 research aspects:

(1) How is dealt in the Dutch and Flemish PAN with the scientific uncertainties regarding ND and its effects on Natura 2000 sites?

(2) How is the Environmental Utilization Space for Nitrogen Deposition (EUS-ND) determined and who is involved in this determination?

(3) How is the "Monitor-Learn-Adapt (MLA)- principle" applied in the Dutch and Flemish PAN?

(4) What trade-offs in the permitting process determine the balancing of socio-economic development and nature conservation interests and which actors influence these trade-offs?

(5) Which findings from the Dutch and Flemish PAN cases can be translated into more general design-principles for a Programmatic Approach in environmental governance?

In the following sections we will explain the theoretical framework with the EUS-ND model in section 2 and the research approach and methodology in section 3. The results of the case studies are reported in section 4 and summarized per research sub question. A detailed table with observations in the Dutch and Flemish PAN case study is added in appendix 1 and 2 respectively for traceability.

2. The EUS-ND as Theoretical Framework

This research uses a theoretical framework that is based on the Environmental Utilization Space concept that was introduced by Opschoor. (Opschoor, 2008). "Utilization" of the environment" is a wide notion: it refers to limited (renewable) resources that the biosphere generates and that are consumed directly by humans, but also to anthropogenic waste streams that are absorbed, purified, and regenerated into new resources (Opschoor, 2008, p. 75). The utilization space should not be exceeded at the expense of future generations. Further, Opschoor states that the Environmental Utilization Space does not fully represents Nature's value because nature and its species have intrinsic value as well.
The Deposition of reactive Nitrogen that is studied in this thesis is an example of an anthropogenic waste stream for which many habitats have a limited bearing capacity. Therefore, we name the theoretical model in this thesis the "Environmental Utilization Space for Nitrogen Deposition (EUS -ND)" (see Figure 2).

The EUS model in this thesis is represented by a triangle with *EUS creation* as input and *EUS consumption* as output. The input and output are managed with a Programmatic Approach and should be in balance, or, in the case of an exceedance of the boundary, should be brought back in balance by reducing the consumption and increasing the creation. The corners of the triangle in figure 2 show the 3 research aspects that influence the effectiveness of the PA: uncertainties, trade-off influences, and the Monitoring-Learning-Adaptation (MLA)-principle. Below, the EUS model with input/output and its research aspects are defined further using stipulative definitions as the basis for the two case studies in this thesis.

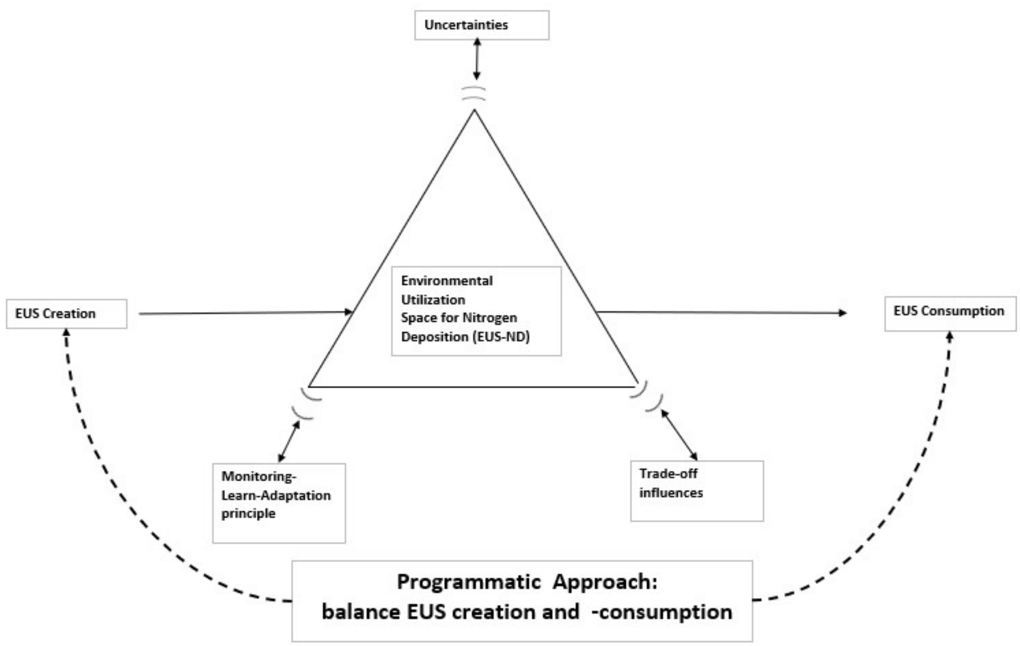

Figure 2: Environmental Utilization Space for Nitrogen Deposition (EUS-ND)- model. *The EUS creation consist of ND lowering measures like emission reductions that are taken as part of the PAN. The EUS consumption consists of activities that cause ND on the Natura 2000 habitats. The Programmatic Approach aims to balance the creation and consumption of ND.*

<u>EUS ND & critical load:</u>
EUS ND represents the amount of space that is still available for consumption by emitting reactive nitrogen that deposits on vulnerable Natura 2000 habitats. On many habitats this is a negative value because the critical load (see footnote on page 7) is already exceeded. Other area's still have ND-bearing capacity and their critical load is not yet exceeded. Additional ND space can be created by measures in the PA like emission reduction measures and habitat recovery measures that make the habitats more resilient to high ND levels. The measures that limit the consumption of ND space consist of a permitting system that regulates the activities that are still allowed and under what conditions these activities can be permitted.

A few comments can be made with regards to this definition. Regarding the EUS concept, Van Assche & De Jonge argue that the EUS is not a fixed amount that can simply be determined through scientific data and observations. Rather, the EUS varies in value depending on how various persons (or groups of persons and their discourses) appreciate the EUS in question, apply the precautionary principle and claim their part of the EUS or leave it for consumption by others and future generations (Van Assche & De Jonge, 2001, p. 15). Beekman confirms this in his paper about the relation of EUS with sustainable development.

Beekman emphasizes the lack of scientific certainty in quantifying the EUS. Further, the individual's social survival dilemma [4], the far-reaching influence of science and technology in our society and natural environment, and risk perception play an important role in quantifying the EUS (Beekman, 2004, p. 298). We acknowledge these remarks, and they show the importance of the research aspects (corner points of the triangle) in this research.

Two more comments must be made regarding the EUS model: First, the Environmental Utilization Space under study cannot be completely disconnected from other EUS-es that impact an ecosystem. The EUS for ND and the critical load of ND that an ecosystem can bear, depends on other pressures like drought, fragmentation or invasive species that are pressures that have their own EUS. Secondly, an EUS as considered in this study applies to a certain part of the environment. In this study that particular part consists of the Dutch and Flemish nitrogen sensitive Natura 2000 habitats. The conservation status of these habitats depends not only on ND levels and other pressures, but also on the status of nature and species outside the Natura 2000 habitats. In this thesis however we will make the demarcation to consider only ND on Natura 2000 habitats.

Programmatic Approach

A programmatic approach is mainly used to manage the funding and execution of a program with environmental projects linked to an certain area or theme (Global Environmental Facility (GEF), 2017; Green Climate Fund (GCF), 2020). The Programmatic Approach in this theoretical framework however is the environmental governance tool to balance a particular EUS, including its creation and consumption, in an effective way with the aim to stay within the boundaries and sustain it for future generations.

The principle of the PA is that the EUS is maintained (or increased) if the created EUS equals (or is larger than) the EUS that is consumed. As such, economic (EUS-consuming) activities can grow if the PA also compensates these with EUS creation activities to maintain or increase the size of the EUS. Not the individual EUS-consuming or -creating projects or activities within the program, but the program as a total should guarantee that the EUS is in balance. This characteristic makes PA's flexible and adaptable governance instruments that allow for economic development and innovation while, at the same time, it limits the administrative burden of assessing each human activity individually (Squintani et al., 2017).

The key concept "Programmatic Approach" is operationalized in the PAN case studies by the "Programmatic Approach to Nitrogen" in the Netherlands and in Flanders from its initiation in 2015 until the annulment in May 2019 and February 2021 respectively.

Uncertainties

In environmental research and environmental policy making, uncertainty can be looked at as conflicting representations of reality (Tuinstra, Ragas, & Halffman, 2019, p. 105). Various types of uncertainty can be distinguished:
1) Because of the complexity of environmental problems, different understandings or 'frames" exist about these representations. The frames are based on different perspectives that different groups or individuals have about the problem. In the EUS model, frames and framing is closely related to the different risk perceptions and the way science and technology are valued.
2) Limited scientific knowledge is a second type of uncertainty in environmental problems and can be caused by limited data and inaccurate measurements. More and better observations can reduce this type of uncertainty and improve or adapt our representation of the reality. The observations and learnings to adapt our representation of reality is operationalized by the research aspect "MLA-principle" discussed below.
3) representation of the state of nature is often characterized by variability. This type of uncertainty, caused by randomness and chaotic behavior of socio-ecological processes, is a given and cannot be reduced by more data or more accurate measurements.

This research focusses on the uncertainty type 2) and 3) as research aspect of the EUS: The scientific uncertainties regarding creation and consumption of EUS, the resulting size of the EUS, and the capability and resilience of the EUS to bear the pressures of human activity. These types of uncertainties can be operationalized in the PAN cases by analyzing the:
-uncertainties regarding accuracy of ND determination and measurements;
-uncertainties in the value of critical load and thresholds used in the PAN;
-uncertainties in the impact of ND on ecosystems in Natura 2000 areas;
-uncertainties in the effects on ND reduction measures;
-uncertainties in the effects of nature recovery activities that are part of the PAN
The first uncertainty, different understandings or "framing", by, for example, farmers associations, politicians, NGO's, and scientist, do play an important role in the Dutch and Flemish PAN but are not considered in this thesis because we aim to keep the objectivity in finding weaknesses and strengths in the Dutch and Flemish PAN cases.

[4] The "social survival dilemma" is described by Steg & Vlek as the phenomenon that drives people to make choices in their own advantage rather than for the benefit of other, non-related people. We argue that this phenomenon can be applied to the behavior of individual businesses as well (Steg & Vlek, 2010, p. 120)

Monitor-learn-adapt (MLA)-principle:

The monitor-learn-adapt (MLA)-principle aims to (1) increase knowledge by learning from monitoring, (2) reduce uncertainties, and (3) adapt the plan based on the new knowledge to be more effective in reaching the objectives. By effective monitoring and learning from the monitoring results, uncertainties can be reduced, and the knowledge base can grow. This is of particular importance for environmental policymaking because in socio-ecological systems the uncertainties are often large and knowledge about how the system works is limited (de Graaf et al., 2018). Monitoring, learning, and adaptation are also key elements in the "Ecosystem Approach (EA)" that was developed by the Convention on Biological Diversity (CBD) (Secretariat of the Convention on Biological Diversity, 2004, pp. 37, 38):

"*The Ecosystem Approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Ecosystem processes are often non-linear, and the outcome of such processes often shows time-lags. The result is discontinuities, leading to surprise and uncertainty. Management must be adaptive in order to be able to respond to such uncertainties and contain elements of "learning-by-doing" or research feedback" (Secretariat of the Convention on Biological Diversity, 2004, p. 1)*

The relevant principles, guidelines and/or annotations in the EA-framework for the setting of this research are:

- "Ecosystems should be managed for their intrinsic value and for the tangible and intangible benefits, taking different societal views and interests into account in a fair, equitable way" (principle 1) (Secretariat of the Convention on Biological Diversity, 2004, p. 8)
- "Ecosystems should be managed within the limits of their functioning" (Principle 6) and "because of uncertainties, managing ecosystems should be adaptive with a focus on learning from the monitoring to effect of planned interventions using a sound experimental approach" (annotation to principle 6) (Secretariat of the Convention on Biological Diversity, 2004, p. 18), and implementation guideline 6.9 to "formulate, review and implement regulatory framework, codes of practice and other instruments to avoid using ecosystems beyond their limits (Secretariat of the Convention on Biological Diversity, 2004, p. 19)
- "The EA approach should be undertaken at the appropriate spatial and temporal scale" (principle 7), especially the monitoring and assessment (implementation guideline 7.5). This often means a decentralization of natural resource management (guideline 7.2) (Secretariat of the Convention on Biological Diversity, 2004, p. 21)
- The EA should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations, and practices (principle 11). The Implementation guideline 11.2 of this principle emphasizes to apply the best available expertise, including the knowledge and views of all stakeholders (Secretariat of the Convention on Biological Diversity, 2004, p. 29);

In summary: recognition of complexity, constant change, and lack of knowledge is at the core of the EA and protection institutions must be capable to adapt, provide constant monitoring of progress, and cope with surprise and uncertainty (Karkkainen, 2002).

The MLA-principle will be operationalized in the PAN cases by studying and analyzing the type, frequency, and methods of monitoring applied regarding ND in natura 2000 areas. Further, this principle is operationalized by analyzing the way monitoring data is shared and discussed with stakeholders in order to learn from the results, and if and how the PAN is adapted to improve its effectiveness based on these learnings.

Trade-off influence:

During the execution of a Programmatic Approach, choices must be made by authorities regarding permit requests and by businesses regarding investments or change of activities that positively or negatively impact the EUS. These decisions can be made with a certain degree of freedom. The more freedom authorities and business have in making their choices, the more the EUS is influenced by their trade-offs. Consumers of EUS-ND space make trade-offs about investments for expansions or emission reductions. Competent authorities make decisions about the amount of ND that is consumed, under what conditions, and how new ND space can be created. Hence, the effectiveness of Programmatic Approaches depends on the discretion of public authorities that trade-off restoration efforts and economic development (de Graaf et al., 2018; Schoukens, 2015; Squintani & Zijlmans, 2019).

In the Dutch and Flemish PAN cases, the trade-off aspect will be operationalized by studying how competent authorities make their choices regarding assignment of permits and its prerequisites such as source measures or recovery/compensation activities. Political trade-offs, for example about the degree of regulation enforcement are not considered in the case studies.

The table below summarizes the key concepts of the theoretical framework

Key concept	**Demarcation**	**Operationalization** (how to observe in empirical research)	**Alignment with research objective/questions**
Programmatic Approach (PA)	-**PA in environmental governance** -Characteristics in the design of PA's -Specific research aspects of PA	PAN in the Netherlands and PAN in Flanders	Improve the design of PA as Environmental Governance instrument to manage EUS and its critical load
EUS and critical load/quality standards	-EUS with creation and consumption and critical load that are governed with a Programmatic Approach	-ND Critical load, Deposition Room, Recovery measures and source measures	Programmatic Approach to Nitrogen as valuable case of strengths/weaknesses of the PA
PA aspect "Uncertainty"	-scientific uncertainty and variability for EUS, critical load, creation and consumption of EUS -**Not: framing and knowledge controversy**	-uncertainties in effects of restoration measures and source measures. -Accuracy of ND models and measurements -uncertainties in ND prognosis	-Knowing what the uncertainties are in the PAN, and how these are managed/ reduced,
Monitor-learn-adapt-principle	-**Ecosystem Approach** perspective of Monitoring-learning adaptation -acknowledgement of non-linear character of ecological processes, tipping points and "surprises"	-Monitoring of ND and the effects of ND -Monitoring of PAN source and restoration measures -the process of assessment of the above monitoring results, the learning process and the adaptation of the program accordingly	
EUS creation	All human activities and natural processes that provide or create new EUS	-restoration and source measures on Natura 2000 area's that create room for new activities	Creation of EUS-ND (Space for new ND or "ND room" in the PAN) is a key element for a PA in general and considered a critical element in the design of a PA
EUS consumption	All human activities and natural processes that provide or create new EUS	-all human activities that cause ND on N2000 area's	
Trade-off influence	Degree of freedom in choices made by businesses and authorities that apply the Programmatic Approach	-Choices related to permitting procedures -Choices by businesses and landowners related to investments and cooperation with the PAN measures	Study of trade-offs as key aspect of PA's

Table 1: Summary of the stipulative definitions with demarcation and operationalization for this research*. These are as per (Verschuren & Doorewaard, 2016, p. 131) and aligned with the research questions.*

3. Research Approach and Methodology

To gain better insight in the success/fail factors for a Programmatic Approach, two case studies will be conducted: The Dutch and Flemish PAN cases. The methodology of Case studies is suitable to obtain the necessary study depth, take an explorative, holistic approach and allow flexibility to go in more detail on certain parts as needed. These characteristics of a case study are important to find relevant experiences with the PAN and obtain proper understanding about the experiences in the Dutch and Flemish PAN.

In the case studies, research documents are qualitatively analyzed by deductive coding using the codes in table 2 below. The initial codes "uncertainty", "trade-off", and "Monitoring" expanded with sub-levels during the case study as new insights became available. The research questions are used as main guideline to decide if a code was added or not and if it would bring more or better observations as basis for answering the research questions. This iterative process is shown in Figure 2 below by the dotted line.

In total, 37 codes are applied, and 512 quotations are reported from 39 research documents. The dummy code "Note" was used to mark document parts that had general information value but not directly relate to one the research questions.

The main criteria for the selection of the research documents were (1) the expected information density, (2) neutrality and relevance for the research aspects; (3) role and authority of the author(s), and (4) the studied time-period being 2014-2021. A brief overview of the research documents and its relevance to the case study is given in the introduction section of each case study.

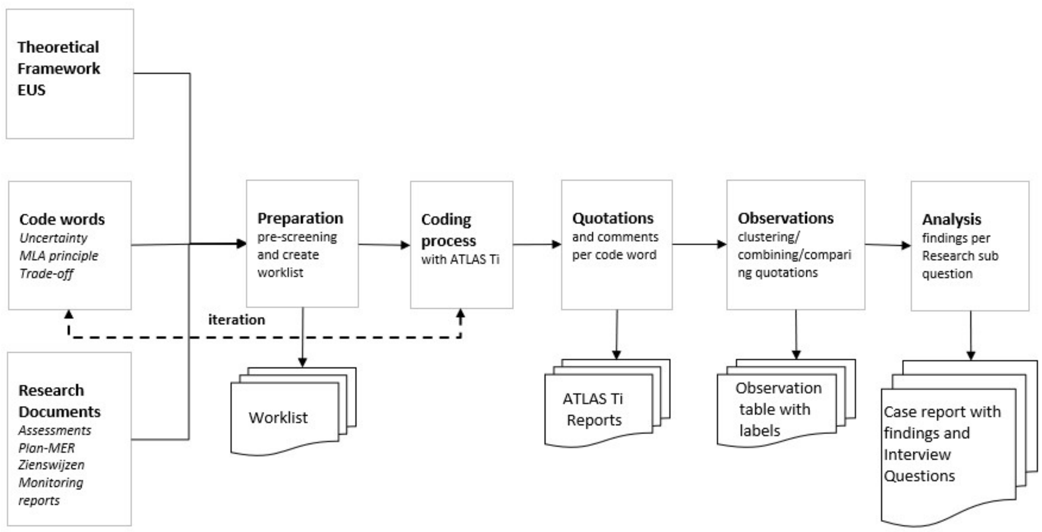

Figure 3: Flowchart of the case studies with the coding process and deliverables

As preparation for the deductive coding, the research documents were briefly screened, and parts were highlighted. During this preparation activity, a case study work list was established with directions for further emphasis on certain parts of the document or a certain sequence of studying them. For example, certain documents relate more to the planning of the PAN, others to the developments during the execution of the PAN. Some parts of the research documents were skipped and marked as "to be excluded from the scope of the case study".
Other comments in the worklist related to possible adjustments of the Theoretical Framework or if parts could better be incorporated into the discussion part of the Thesis.

Coding step
In the next step "Coding process", the documents were studied and coded. Atlas Ti version 9 was used as coding tool and to generate reports with quotations and quotation comments per code. For most quotations, a comment was added with initial analysis remarks, questions that were triggered by the quotation, or suggestions for further factchecking and triangulation. Comments were also added about how the quotation related to one or more research questions: Is it evidence for a certain kind of uncertainty? Does the quotation support the MLA principle and how? How does a particular quotation introduce a trade-off for a stakeholder in the PAN? Does the quotation answer a question that was raised as a comment earlier in the case study? Does the quotation give a new perspective on the Theoretical Framework or other related concepts? In this intensive coding process, an 'holistic approach with and open mind' (Verschuren & Doorewaard, 2016, p. 180) was applied with attention for deep-drilling where needed.

Quotations and Atlas Ti reports

In the next step, quotation reports were generated from the ATLAS Ti database. The reports were exported into excel format for further sorting and filtering. The report contained all quotations with comments including the document name, page number and code number for traceability in the reporting.

Create observations

The ATLAS Ti reports were input for the "Observations" step in which the quotations with comments were analyzed and observations were generated. In this step, the quotations were filtered per code, duplications were removed, and initial findings were concluded. Relations between quotations were analyzed and formulated into observations. Examples are developments regarding the MLA principle, differences in perceived uncertainties or contradictions in reported emission quantities. For correct referencing, the document and page number of quotations were double checked and corrected as needed. During this process, 'fact-checks' were done using google scholar or on specific websites (like the Natura 2000 website or the website for Best Technologies for emission reduction measures). Further, the Observation step included many iterations, crosschecks and 'deep-drilling' on certain observations by studying references and application of source triangulation (Verschuren & Doorewaard, 2016, p. 180). In some cases, the code was changed or in case of multiple codes per quotation, it was assessed if the quotation fitted better with 1 of the codes or if the quotation had value for answering more than one research sub question. Linking observations to research questions was an important part of this step. About 20% of the quotations were quoted with the dummy code "note" because of the possible general information they contained that could be used for general description of (elements of) the PAN. The observations were labelled for easy reference to the research questions.

The result of the observations step was an observation table per case study with labels, analysis findings per research question, and suggestions for interview-topics. The observation tables are added as appendix to the report. In the results section 4, frequent references are made to the observation table to enhance traceability of the findings.

Analysis, case report and interviews

As last step in the case study, the observations table was analyzed, and the findings were reported in answer to the research questions. A selection of 6 interview topics was made based on the "blind spots" in the findings. Blind spots are parts of the research aspects that are believed to be an important element in a PA but are not sufficiently answered in the case study. The interviewees were selected based on their expertise in that interview topic. The interviews were semi-structured and left room for elaboration on the interview topic and on the experiences with the PAN in general. Findings from the literature study were briefly discussed as well if it related to the expertise field of the expert. The interviews questions were sent to the interviewee upfront and a summary of the interview was sent afterwards for comments and approval.

During the case studies, the intermediate results were reflected upon regularly to keep the format and reporting of observations in both case studies comparable per research question. This reflection helped to indicate different names for similar concepts in the Dutch and Flemish PAN. It must be noted however the main objective of the case studies is not to compare the Dutch PAN with the Flemish PAN but to obtain findings on weaknesses and strengths of both PAN instruments.

The table below gives an overview of the codes that are applied during the coding including the code- definition and the link to the research question. During the coding process, the list of codes developed into more specific codes to distinguish different types of uncertainty and trade-offs or different elements of the MLA principle.

The same codes were used for both case studies except for the coding for the ND model AERIUS in the Dutch PAN case and VLOPS model in the Flemish case.

Code	Research Question	Code Definition
Critical Load (KDW)	• Question 2 (ND room determination, who is involved and How?	KDW: de grens waarboven het risico bestaat dat de kwaliteit van het habitat significant wordt aangetast door de verzurende en/of vermestende invloed van atmosferische stikstofdepositie
Uncertainty Legal Framework	• Theoretical Framework • Question 4 Trade-off ND and Nature Conservation • Question 1 Uncertainties	The complex of EU directives, laws, decreets and resolutions that are part of the PAN or related to the PAN and the nitrogen emission and deposition problem
MLA (monitoring-Learn-Adapt)-principle	• Question 3 Monitor-Learn-Adaptation-principle	The principle as described by the Ecosystem Approach with the elements Monitoring, Learn, and Adaptation. Consultation & Information sessions, perusal periods, evaluations and findings and adjustments following these instruments are examples of the Monitoring-Learn-Adaptation (MLA)-principle
MLA-principle - AERIUS/VLOPS	• Question 3 Monitor-Learn-Adaptation-principle	VLOPS (Flemish PAN) or AERIUS ND calculation and accounting system (Ducth PAN) as part of the MLA-principle
Monitoring - Conservation	• Question 3 Monitor-Learn-Adaptation-principle	MLA activities specifically for nature conservation
ND Room Calculation	• Question 2 (ND room determination)	This code applies to texts about the definition and/or calculation or determination of the Nitrogen Deposition Room in the Dutch PAN
Trade-off	• Question 4 Trade-off ND and Nature Conservation	This code is applicable for general cases of a trade-off by a person or group of persons in order to take a decision related to the PAN. Trade-off in this casestudy is defined as the balancing act between nature conservation and economic interests at various levels (national, regional, local) and within various institutions (governmental, NGO's, businesses)
Trade-off - Recovery	• Question 4 Trade-off ND and Nature Conservation	Trade-offs related to recovery measures, between various competing recovery measures or between recovery measures and other environmental interests
Trade-off - Source Measures	• Question 4 Trade-off ND and Nature Conservation	Trade-offs related to the application of PAN source measures like the decision the y/n invest or y/n comply to agreements and regulations
Trade-off ND Room	• Question 4 Trade-off ND and Nature Conservation	Trade-offs related to the ND Room, ND consumption (output) or ND creation (input)
Uncertainty - Recovery	• Question 1 Uncertainties	Uncertainties defined as knowledge gaps related to effects of recovery measures and the uncertainties regarding (timely) execution of the measures
Uncertainty - Source	• Question 1 Uncertainties	Uncertainties regarding the effects of source measures with regards to emission control and the execution of the measures by farmers
Uncertainty - AERIUS/VLOPS	• Question 1 Uncertainties	Uncertainties related to AERIUS/VLOPS as major elements in respectively the Dutch and Flemish PAN
Uncertainty - Gebiedsanalyse	• Question 1 Uncertainties • Question 2 (ND room determination)	Uncertainties related to Natura 2000 area analysis,(Further "Natura 2000 area-analysis" or "area-analysis)
Uncertainty - Legal	• Question 1 Uncertainties	Uncertainties related to Legal robustness of the PAN as basis for permitting
Uncertainty - ND Consumption	• Question 1 Uncertainties	Uncertainties related to ND consumption. ND Consumption exist of all activities that consume ND room which is therefore not available for habitat recovery and/or protection of sensitive habitats against high ND.
Uncertainty - ND Measurements	• Question 1 Uncertainties • Question 3 Monitor-Learn-Adaptation-principle	Uncertainties related to the determination of ND. ND is defined as the wet or dry deposition of reactive nitrogen.
Uncertainty - Prognosis	• Question 1 Uncertainties • Question 2 (ND room determination)	Uncertainties in the prognosis of ND that was done by the Government based on the autonomous downward trend as result of current policies ("Business as Usual" scenario in the Flemish PAN)

Table 2: Applied codes during the deductive coding in the case studies

4. Results

The effectiveness of a Programmatic Approach is expected to depend on how it deals with uncertainties and how uncertainties are reduced by applying the Monitor-Learn-Adapt-(MLA) principle. Besides, a PA should give guidance to competent authorities to make trade-offs between nature conservation and economic development (see also section 2 Theoretical Framework).

This section describes the results of the Dutch and Flemish PAN cases in which the research aspects "uncertainties", "MLA-principle" and "Trade-off influences" as studied. We start with a high-level overview of the Dutch and Flemish PAN cases in paragraph 4.1. Then the results are reported per research aspect in paragraph 4.2, 4.3 and 4.4. In the concluding paragraph 4.5 the results are summarized and combined into a summary table with the strong and weak PA-elements in both cases.

4.1 Overview of the Dutch and Flemish PAN

The Dutch and Flemish PAN are the main governance instruments to improve the conservation status of nitrogen-sensitive natura 2000 habitats. The PANs consist of ***source measures*** to reduce the nitrogen deposition, and a ***permit mechanism*** to regulate new activities. The PAN source measures are taken in addition to a prognosed ***downward trend*** as result of current policies that prescribe cleaner technologies for transportation, industries and other NOx emitting processes. The levels of ND caused by NH3 still remain high and do not show this downward trend (Folkert et al., 2014, p. 29; Vlaamse Milieumaatschappij, 2019).

The balance of the source measures and downward trend on the one hand (ND room creation), and the permitting of new activities (ND room consumption) should bring the ND levels below the Critical Load so habitats can recover and improve their conservation status (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 7; Schauvliege, 2016a, p. 3). See figure 4.1 below.

The Dutch and Flemish PAN also prescribe ***recovery measures*** that intend to increase the resilience of habitats against the high ND levels. Examples of recovery measures are hydrological measures, the removal of nitrogen rich soil layers, mowing schemes, and other measures to remove reactive nitrogen molecules from habitats or mitigate their effects (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 20; Schauvliege, 2016a, p. 2).

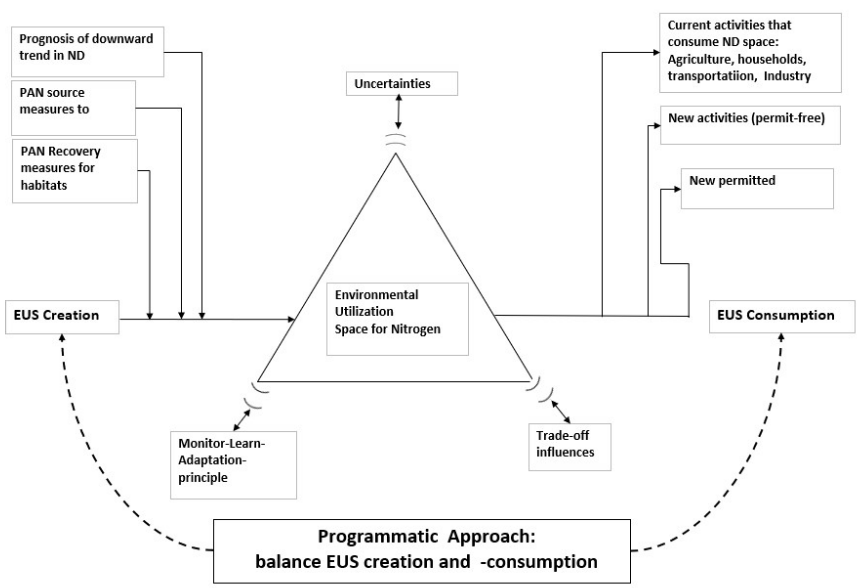

Figure 4.1: The translation of the EUS model to the Dutch and Flemish PAN*. The figure shows the source measurements and autonomous development downward trend that create ND room for new activities.*

Both the Dutch and Flemish PAN are based on Natura 2000 area analysis in which for each individual area the ecological status is assessed and evaluated what recovery measures are needed (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 22; Schauvliege, 2016a, p. 23). In the Dutch PAN case, the Natura

2000 area analysis is also used to quantify the available ND room for new activities. In the Flemish PAN, the area analysis focused on the recommended recovery measures and not on the quantification of available ND room for new activities.

4.1.1 Origin and Timeline of the Dutch PAN

The Dutch PAN finds its origin in the difficulties regarding permitting of activities close to Natura 2000 areas under the Nature Protection Law 1998. This law is the Dutch implementation of the European Habitat Directive that enforces EU member states to maintain or bring back designated Natura 2000 sites into a good conservation status. The Nature Protection Law 1998 prescribed that before permitting new activities, it should be demonstrated that these new activities would not affect the nitrogen sensitive habitats. Since many habitats were already affected by an exceeded maximum allowed ND-level, demonstrating that a new activity had no impact appeared to be impossible in many cases (Doekes, Nijboer, & Bekker, 2015a, p. 27). This caused a stagnation of permit approvals for, in particular, the expansion of cattle farms nearby Natura 2000 area's (Doekes et al., 2015a, pp. 7, 27).

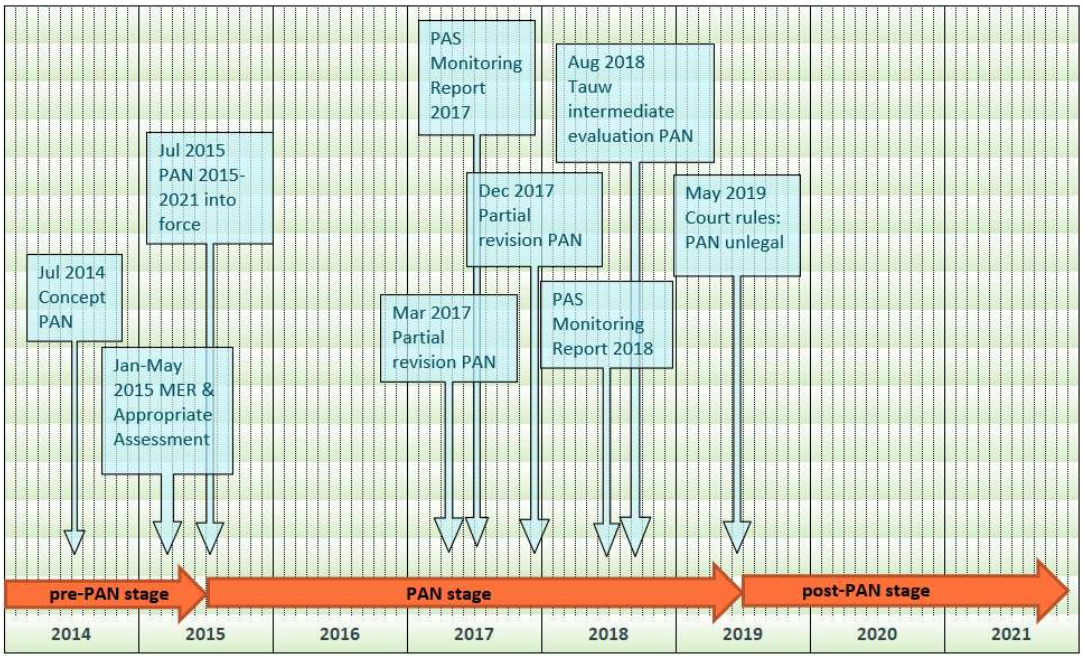

Figure 4.2 The Dutch PAN timeline with main milestones and the stages pre-PAN, PAN and post-PAN

The Programmatic Approach to Nitrogen is an adjustment of the Nature Conservation Law 1998 article art 19 and was created to unlock the permitting process with a new legal framework (Folkert et al., 2014, p. 8). Within this framework, the ND room that was made available could be used for permit-free activities (below 1 mol/ha/yr ND) and activities that need to follow the nature law permitting procedure (≥ 1 mol/ha/yr ND). A list with priority projects was established and incorporated in the PAN. The priority list is evaluated regularly and consists of infrastructural projects that have a high priority compared to individual businesses like farms (Folkert et al., 2014, pp. 34, 35). The remaining ND room per Natura 2000 area was available for other activities as per first come, first served principle. Besides, the PAN described the basic requirements to avoid further deterioration of the Natura 2000 area conservation status: (1) stop the deterioration of the conservation status of nitrogen sensitive Natura 2000 area's; (2) bring habitats and species in a good sustainable conservation status; (3) the PAN should lead to a sooner decrease of ND than with the autonomous decrease only; and (4) (as per ruling by the Dutch Court of State) the PAN should not lead to a disproportionate later realization of a good conservation status by assigning new ND-room for ND creating economic activities (Folkert et al., 2014, pp. 38, 39, 41).
The PAN covers all nitrogen sensitive Natura 2000 areas in one program and this program is appropriately assessed in accordance with the HD art 6.2 as a whole. This means that no individual Appropriate Assessments for new projects or activities were needed from the moment the PAN entered into force.

As shown in figure 4.2, we can distinguish 3 stages in the Dutch PAN timeline: pre-PAN stage, PAN stage and the post-PAN stage. In the pre-PAN stage, the plan-MER with Appropriate Assessment was conducted, study reports on the concept PAN, like the Planbureau voor de Leefomgeving (PBL) Assessment-report by Folkert et al., were published and viewpoint-opinion documents ("zienswijzen") by many stakeholders were submitted and answered (see: (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b)). The pre-PAN stage resulted in the release of the first version PAN in July

2015. In the PAN-stage, monitoring reports like the intermediate evaluation report by Tauw (Bekker & Heijligers, 2018) were published and the PAN was revised in March and December 2017. The PAN-stage ends with the Court ruling in May 2019 that ended the legal force of the PAN because it was declared in conflict with the HD by the Dutch Court of Justice (Afdeling Bestuursrechtspraak van de Raad van State (ABRvS), 2019).

In this case study, only the pre-Pan and PAN phase are analyzed. In the post-PAN stage the Programmatic Approach could not be applied any further for the balancing of ND between the nature conservation objectives and economic activities because of the court ruling on 29 May 2019. Therefore, this stage is not considered in the casestudy.

4.1.1.1 Research documents in the Dutch PAN case study

For the pre-PAN stage, the main research documents are the:

- PAN assessment report by the PBL (Folkert et al., 2014);
- Environmental Effects Report for the PAN (plan-Milieueffectrapportage) part 1 and 2 (Doekes et al., 2015a) the addendum and explanatory note (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015a) and the assessment recommendations by the executing Commission (Commissie voor de Milieueffectrapportage, 2015);
- Viewpoints with the response note on the viewpoints (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b).
- Monitoring reports by TAUW, the PAS-bureau, and the RIVM

The PBL report gives an in-depth assessment of the concept-PAN and gives valuable information about uncertainties and the way the PAN was planned to apply monitoring and adjustments. The Environmental Effects Report (plan-MER) parts 1 and 2 establish the link with HD art 6.3 obligation to appropriately assess activities that can negatively impact Natura 2000 sites. As part of the public review of the Dutch PAN, hundreds of viewpoints were submitted by dozens of parties and individuals. The response note to these viewpoints is studied to obtain information about the perspectives and interests that various stakeholder had, and which trade-offs were important in the Dutch PAN case.

During the PAN stage, the midterm evaluation was conducted and reported by TAUW, and the PAN was adjusted two times in March and December 2017. Because the AERIUS monitoring and reporting tool is a core element of the MLA system in the Dutch PAN, a more extensive analysis of this tool, its reviews and its developments was also part of the case study.
The analysis of the pre-PAN stage documents focused on the initial findings related to the research aspects. In the analysis of the monitoring reports during the PAN stage, the focus shifted more to the developments regarding uncertainties and trade-offs, and the application of the MLA principle.

4.1.2 Origin and Timeline of the Flemish PAN

The Flemish PAN originates from April 2014 (Schauvliege, 2016a) when the Flemish government designated the Natura 2000 Area's with its conservation objectives ("Speciale Beschermingszones met instandhoudingsdoelstellingen). At the same time, it was decided by Decree (Belgisch Staatsblad dd 15-10-2014) to set up the Natura 2000 program and to develop a Programmatic Approach to deal with one of the most important environmental pressures: Nitrogen Deposition. As such, the Flemish PAN is closely entangled with the Natura 2000 program and can be considered a Natura 2000 sub-program (Agentschap voor Natuur en Bos (ANB), 2017a, p. 26).The legal basis of, and requirements for the Flemish PAN are stipulated in the Nature Decree art 54ter par 4, that prescribes that a programmatic approach should at least consist of an area analysis regarding the environmental pressure as basis for source measures and recovery measures to avoid further deterioration of the conservation status.
The Flemish Natura 2000 policy acknowledges multiple pressures that hamper the improvement of nature conservation. ND is one of the most important pressures besides fragmentation, climate change, etc. (Geeraerts, 2014, p. 10). The integration of the PAN into the Natura 2000 program shows a long-term integrative approach within the same N2000 framework and can be considered a strong point in the Flemish PAN.

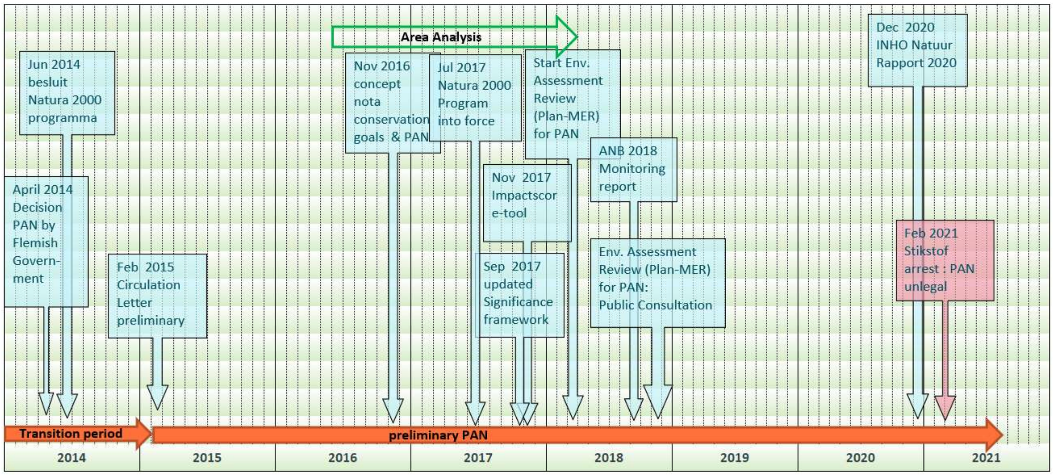

Figure 4.3: The Flemish PAN timeline with main milestones

The quantification and permitting of ND consumption in Flanders is operationalized using a significance framework (Agentschap voor Natuur en Bos (ANB), 2015, p. 23) that distinguishes activities with significant and activities with non-significant impact on Natura 2000 areas. In this assessment, the total contribution of the activity to the Critical Load on each habitat-cell is determined. If the activity contributes >3% to the CL on at least 1 habitat-cell, the activity is considered significant. In that case, at least 30% reduction of the total contribution must be realized before the permit can be extended, or new activities can be permitted. In the case that the contribution of the permitted activity is > 50% of the CL, renewal of the permit will not be approved, and the activity must be phased out (Agentschap voor Natuur en Bos (ANB), 2015, pp. 25, 26). For activities that contribute < 3% to the CL, no permit request is needed.

Besides the significance framework, a list of green, orange, and red activities, mostly farms, was generated (KENTER, 2018, pp. 24, 25). The red farms were planned to stop their activities in due time. The orange farms only could be re-permitted and continue their activities if emission reduction measures were taken. A restructuring budget was agreed to financially compensate targeted farms that could not continue their activities.

For the modelling and calculation of ND, a Flemish version of the Dutch Operationeel Pioritaire Stoffen (OPS) model was combined with IFDM (Immissie Frequentie Distributie Model) in 2015. OPS is also the core calculation tool behind AERIUS and the Dutch and Flemish models are therefore comparable (Lefebre & Deutsch, 2015, p. 2).

The preliminary Flemish PAN was initiated with a circular letter by the Flemish Minister of Environment, Nature and Agriculture on February 20th 2015. This letter explained the permitting requirements and the related PAN tools like the "pre-assessment tool" and the "roadmap" (praktische wegwijzer eutrophiering via lucht). This circular letter gave the interpretation of the art 36 par 3 and 4 of the Nature Decree concerning activities that have significant effects on protected Natura 2000 habitats (Schauvliege, 2015). The Natura 2000 area analysis for the Flemish PAN were ordered and executed in May 2016 for a better understanding of the ecological status and as general basis for the PAN recovery measures (De Keersmaeker et al., 2018).
In November 2016, the concept nota conservation goals and PAN was presented and briefly evaluated in the Flemish Government (Schauvliege, 2016a). This resulted in the establishment of the Natura 2000 program including the PAN in July 2017. This Natura 2000 program contained a set of strategic goals and operational goals to gradually bring the habitats into a good conservation status and/or maintain the good conservation status. Operational goal 3.3 linked the PAN into the Natura 2000 program: "*programmatische aanpak stikstof heeft als doel een beleid te ontwikkelen om de stikstofdepositie op de SBZ's terug te dringen, waarbij (nieuwe) economische ontwikkelingen mogelijk blijven en het niveau van de stikstofdepositie op SBZ toch stelselmatig daalt. Op die wijze wenst Vlaanderen het Realiseren van de Europese natuurdoelstellingen in evenwicht te brengen met een economische realiteit*" (Agentschap voor Natuur en Bos (ANB), 2017a, p. 47).
The Natura 2000 area analysis reports became available in May 2018 and created the basis for the recovery strategies that were developed in parallel to the Natura 2000 conservation goals and the final PAN. Later in 2018, the Environmental Assessment Review (plan-MER) was started including a public consultation and an Appropriate Assessment as per Habitat Directive. The Flemish PAN was planned to be ready in 2019 but never obtained the status "final" because it appeared to be too complex to make it sufficiently legally robust (Vlaams Parlement, 2021). Therefore, the preliminary PAN with its tools remained the governing instrument until a court ruling in the "Ravels-arrest" (Raad voor Vergunningenbetwistingen, 2021) in February 2021 ended the preliminary PAN as basis for permitting procedures for ND creating activities.

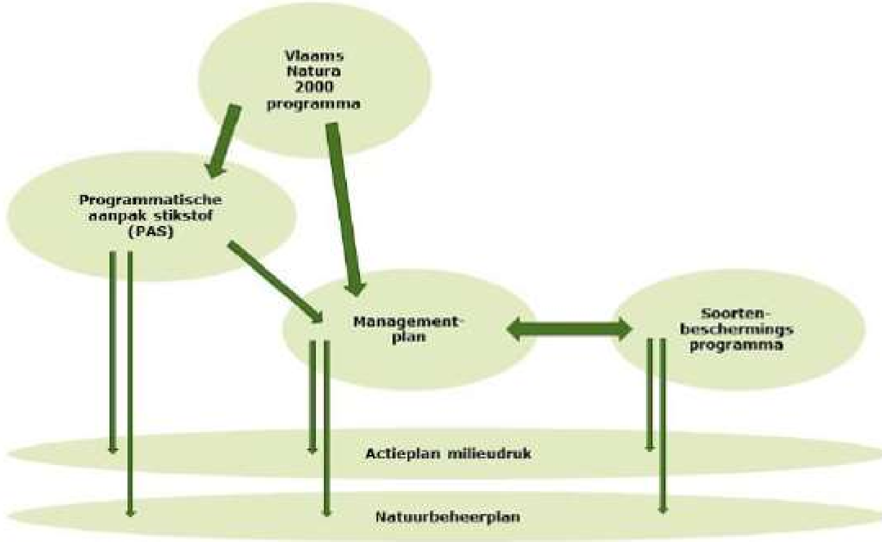

Figure 4.4: The Flemish PAN as sub program of the Natura 2000 program *(source: (Agentschap voor Natuur en Bos (ANB), 2017a, p. 20))*

4.1.2.2 Research documents in the Flemish PAN case study

The Flemish PAN case study is split into 2 parts. In the first part, the planning of the PAN in 2014/2015 is studied. The second part covers the time-period 2016-2021 until the Flemish PAN lost its legal force in February 2021. In the second part, the development of the preliminary PAN is analyzed, as well as the way the PAN was monitored and adjusted as new knowledge and data became available (MLA-principle).

The research documents for the Planning stage of the Flemish PAN include the initiating circular letter in 2015 (Schauvliege, 2015) and the PAN tools. Two guidelines published by the two most important environmental NGO's in Flanders, Natuurpunt and Bond Beter Leefmilieu, about the Nature Decree (Van Gils, 2014) and the PAN (Geeraerts, 2014) are studied because these contain critical notes about effectiveness and shortcomings of the PAN. An in dept review about the air quality models VLOPS and IFDM by Lefebre & Deutsch are studied to obtain insights in the uncertainties and gaps in the emissions and deposition models used in the Flemish PAN (Lefebre & Deutsch, 2015). This publication describes the relation of the AERIUS/VLOPS-IFDM ND calculation model and its uncertainties.

In part 2 of the case study, the emphasis shifted to the monitoring of the program, the developments of the uncertainties, and the adjustments resulting from the learnings and new research. The main documents that are studied in this part of the case study are the:

- Flemish Natura 2000 program, including attachments (Agentschap voor Natuur en Bos (ANB), 2017a). This set of publications describes how Flanders planned to reach a good conservation status for its species and habitats and how the PAN is integrated in this plan. The objections and considerations that were submitted by stakeholders like Farming associations, landowners, industry and environmental associations are listed and discussed in the "considerations" document (Agentschap voor Natuur en Bos (ANB), 2017b);
- Concept nota "Conservation goals and PAN" (Schauvliege, 2016a) by the Flemish government describes the PAN measures, the "Business As Usual (BAU)"-prognosis as basis for the measures, and the steps to be taken to develop the preliminary PAN into a final PAN. This document also shares some learnings and proposals for adaptation following the evaluation of the first PAN experiences in 2015-2016;
- Environmental Effects Report including the notification letter and guidelines (Kennisgeving en richtlijnen plan-Milieueffectrapportage). This set of documents is the input for the PAN- Appropriate Assessment and a public consultation that was conducted between August and October 2018 (KENTER, 2018). The Environmental Effects Report was ready on November 22nd 2018 but was never published and could not be studied;
- Monitoring Plan 2018 by the Vlaamse Milieumaatschappij (VMM) (Vlaamse Milieumaatschappij, 2018) including more recent NOx and NH3 emission data on the VMM website (Vlaamse Milieumaatschappij, 2019). VMM is responsible for the monitoring and reporting of emission data and modelling results;

• Monitoring Plan 2018 by the Agentschap voor Natuur en Bos (ANB) about the PAN recovery measures. ANB is responsible for monitoring and reporting of the progress and effects of the PAN Recovery measures (Agentschap voor Natuur en Bos (ANB), 2018).
• Nature Report 2020 by the Research Institute for Nature and Forest for information about the effects of PAN recovery from ecological point of view (Schneiders et al., 2020).

4.1.3 The main differences between the Dutch and Flemish PAN

The Flemish PAN is very similar to the Dutch PAN: both contain a set of source and recovery measures on top of an expected downward trend in ND levels due to current policies (referred to as the Business as Usual (BAU) scenario in the Flemish PAN). There are interesting differences between the Dutch and Flemish PAN as well: (1) in Flanders, the PAN is clearly embedded in the Natura 2000 program as Programmatic Approach to reduce the effects of environmental pressures that jeopardize the improvement of the Natura 2000 habitats conservation status, and (2) the Flemish PAN is less explicit in applying the ND development room-concept as a quantified amount of ND that can be created, spend, and monitored with the 'hand on the tap principle' [5]. Although the objective of this research is not to make a comparison between the Dutch and Flemish PAN, a table is added below to summarize the most remarkable differences between both PAN instruments.

Dutch PAN	**Flemish PAN**
The concept of ND room in the Dutch PAN is applied and quantified explicitly	ND room concept is rarely used and not quantified explicitly
Dutch PAN is a less clearly integrated into the Natura 2000 program	Flemish PAN is an integrated sub program of the Natura 2000 program
Natura 2000 area's designated and the habitats are fixed before the start of the Dutch PAN in 2015	Natura 2000 area's contain "search zones" 1) in which habitats and economic activities can be assigned as per latest knowledge and insights
Appropriate Assessment as per HD art 6.3 is conducted for the whole PAN program and not per individual project or activity	The Appropriate Assessment as per EU Habitat Directive is part of every permitting procedure
Transparency in the research documents about the uncertainties	Uncertainties in the research documents are not described in a transparent way
1) "Search Zones" ("Zoekzones") are important parts of the Flemish Natura2000 areas for which the habitat-type has not yet been defined. During the process of bringing protected habitats into a good conservation status, these 'blind spots' are used to fit human activities between the protected habitats. Piece per piece the spots are assessed from the perspective of local conservation goals and decided if it must be added to the protected habitat or if it can be used for certain human activities	

Table 4.1: The main differences between the Dutch and Flemish PAN.

4.2 Uncertainties in the Programmatic Approach to Nitrogen (Research Question 1)

To obtain a good understanding about the uncertainties in the PAN cases, various sets of uncertainties are distinguished during the case studies (see also section 3 methodology and section 2 theoretical framework about different types of uncertainties).

Table 4.2 below gives an overview of the sets of uncertainties that are distinguished in the case studies. Some uncertainties can overlap. Uncertainties in source measures for example will also show in the prognosis and uncertainties related to the recovery measures will also be part of the uncertainties in the Natura 2000 area analysis.

The Scientific uncertainty type, characterized by incomplete knowledge and natural variability, can be found in all uncertainty sets. Examples are the influences of weather conditions on the amount of nitrogen deposition, or the effects of recovery measures on the resilience of ecosystems. It must be noted that a degree of "framing"[6] of the data plays a role in the Dutch and Flemish PAN cases but this is kept out of the scope of the case studies as much as possible by choosing 'neutral' research documents that do not have a dominating perspective.

[5] The "hand on the tap-principle" in the Dutch Pan is the metaphor used to explain the creation and spending of ND room like a continuous flow of liquid from a reservoir that is controlled by a tap (Folkert et al., 2014, p. 23)

[6] Framing is defined as a process in which a certain interpretation is given to a problem or situation and frames "identify and give meaning to a situation by defining what it is, what facts about it are the most relevant and what other situations it is related to" (Esther Turnhout, Tuinstra, & Halffman, 2019, p. 37).

Uncertainties in the Dutch and Flemish PAN		
Uncertainty set	**Uncertainty Description**	**Main uncertainties**
Source measures	Uncertainties regarding the effects of source measures with regards to emission control and the execution of the measures by farmers	• Poor enforceability of the measures and dependency on willingness to cooperate voluntary • Poor datasets for ND and emission measurements • 'Death by a thousand cuts'-phenomenon
Prognosis of the downward ND trend	Uncertainties in the "Downward trend"-prognosis of ND. This downward trend prognosis by the Dutch and Flemish Governments was based on the current (2014-2015) policies	• Uncertainties in the size of livestock and effects of suspending of the milk quota (Dutch PAN) • "Stagnation-effect" and "dormant room"-effect (Dutch PAN) • Unclear effect of development of livestock (Flemish PAN) • Number of farms that relocate or stop their activities (Flemish PAN) • "manure" was missed in Flemish PAN prognosis and "fertilizer" as ammonia emission cause in the Dutch PAN
N2000 Area Analysis & Recovery measures	Uncertainties related to the execution and effects of recovery measures that were planned to make the ecosystems more resilient to ND.	• Many recovery measures are not proven in practice (Dutch and Flemish PAN) • Recovery measures heavily depend on willingness of landowners to cooperate (Dutch and Flemish PAN) • Controversy about Dutch Natura 2000 area analysis with defined ND room (doubtful external analysis and final assessment text, see textbox 1) • Knowledge gap and fragmented data in the Natura 2000 area-analysis (Flemish PAN)
AERIUS, NEMA, EMAV, and VLOPS-IFDM emission and calculation models	Uncertainties related to the use and results of models in the Dutch and Flemish PAN case	• uncertainties in AERIUS/VLOPS-IFDM calculations are reported to be 30% at national scale but can be as high as 70% on a local scale (Dutch and Flemish PAN) • in the EMAV emission model assumptions are made for emission source parameters height, flow, and temperature because data was missing.
ND Room and Critical Load	Uncertainties related to the determination of the ND room available for new activities and the Critical Load threshold	• Certain ND Room consumption and uncertain ND room creation results in an out-of-balance ND room • With the PAN, 10-15% ND reduction is at best between 2015-2030. This means that the CL will still be exceeded on 55-70% of the Natura 2000 areas by 2030
Legal uncertainties	Uncertainties related to Legal robustness of the PAN as basis for permitting The complex of EU directives, laws, decreets and resolutions that are part of the PAN or related to the PAN and the nitrogen emission and deposition problem	• Aim for legal certainty and 'robustness' in the Dutch PAN with no changes or stagnation of the permitting process • Lack of legal enforceability of measures agreed by Covenant in The Netherlands • Some legal uncertainty considered characteristic for the Flemish PAN • Legal uncertainty through Search Area's and "jumper" phenomenon in Flemish PAN

Table 4.2: Overview table with the uncertainty sets that are analyzed in the case studies. Many uncertainties can be linked to the balance in creating and consuming ND room. See also fig 4.1.

In the paragraphs below, the analysis results from the case studies are discussed per uncertainty set. First, the uncertainties in the creation of ND room are discussed in paragraph 4.2.1 to 4.2.4. In the Dutch and Flemish PAN, ND room is created by the current downward trend and PAN source measures. The recovery measures should increase the resilience of ecosystems against the high ND levels. Strictly speaking this is not creation of ND room because it does not lower the ND but in the balance of ND room creations and consumption we consider the recovery measures as supporting the creation of ND room.

The uncertainties in the AERIUS and VLOPS-IFDM models are important for quantification of ND creation and consumption and discussed in 4.2.4. In 4.2.5 the uncertainties in ***balancing the ND room*** are discussed, followed by the legal uncertainties and the legal robustness in 4.2.6.

4.2.1 Uncertainties in the PAN source measures

With respect to the uncertainties in the source measures in the Dutch PAN, two observations can be reported. First, PBL describes uncertainties caused by the lack of controllability and enforceability of the ammonia emission reduction measures. The implementation of and compliance to source measures in the agricultural sector tends to "lag behind" according the PBL and it can be expected that this will also be case for ND source measures resulting in a 25% lower effectiveness than planned (Folkert et al., 2014, pp. 7, 55), see attachment 1 US2. The second uncertainty regarding source measures in the Dutch PAN,

is caused by the weak representativity of emission measurements as basis for calculations and modelling (see attachment 1 US1). PBL gives as example the doubts about the correct use and effectivity of air scrubbers in stables (Folkert et al., 2014, p. 10).
In the Monitoring report 2018 of the Dutch PAN, the controllability and enforceability reported by PBL indeed proved to be a weak point in the Dutch PAN (see attachment 1 US Development): the report describes disappointing results regarding the source measures, mostly due to poor effectiveness of emission control in stables and during manure handling (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2019, p. 41).

The main source measures in the Flemish PAN consisted of stopping the ammonia emitting activities of 'red-list' farms close to vulnerable Natura 2000 area's and reducing the ammonia emissions of "orange-list farms" by 30%. The basis for the red-orange-green-list is the Critical Load and how much of the CL increase is caused by the activity. This was subject to the ND Impact Assessment[7] that took place in 2014/2015 (see attachment 2 FTRO 1&2 and FCL2). This ND Impact Assessment and the resulting impact score was applied to make a ranking of the most polluting exploitations: the red-orange-green-list (Cools et al., 2015, p. 47). The Flemish PAN measures were backed-up by a financial plan, mainly for financial compensation for the farms that would need to stop or relocate their activities (Agentschap voor Natuur en Bos (ANB), 2017a, pp. 50, 51). Like in the Dutch PAN, the effectiveness of the voluntary character of the source measures in the Flemish PAN created serious uncertainties. Early in the PAN stage in 2014, the environmental NGO's Natuurpunt and Bond Beter Leefmilieu (BBL) emphasized their concerns about the voluntary basis of these measures and doubted the willingness of farmers to stop their activities (Geeraerts, 2014, pp. 22, 38). Their concerns appeared to be valid because only 10 of the listed 54 farms indeed stopped between 2015 and august 2021 (see attachment 2 FUNSM 1 & 4). Based on this low percentage, it can be concluded that only a small amount of the planned reduction was achieved.
In general, uncertainties with regards to the source measures like emission reduction technology for stables are poorly described in the studied documents in the Flemish PAN case. Even in the "Business as Usual (BAU)- scenario, that includes the prognosis for 2020 and 2030 emission levels, the uncertainties are not transparent. For example, the "proper performance of installations" which is assumed in the practical roadmap for permitting (Agentschap voor Natuur en Bos (ANB), 2015, p. 32), can hardly be justified (Schoukens, 2021, p. 28). See also attachment 2 FUNSM3.
A remarkable observation regarding uncertainties in source measures is that these are not mentioned in the Monitoring 2018 report by the Vlaamse Milieumaatschappij. The report states that the planned BAU-scenario 2020 "is still achievable" (Vlaamse Milieumaatschappij, 2018, p. 4) but the report is not transparent about the uncertainty margins (see attachment 2 FUNSM2). This lack of transparency shows a weak point in the Flemish PAN because clarity on uncertainties is important to apply the MLA principle adequately.

Another source of uncertainty regarding source measures is pointed out by Natuurpunt & BBL: the very large number of small emitters, the thousands of farms in the 'green' category, remain out of scope for measures. A permitting procedure is not necessary for these emitters or existing permits will even be extended automatically. This list with 'green' farms is comparable to the Dutch farms of which the ND caused by new activities was limited to the < 1mol/ha/yr threshold. In Flanders, this group of many small, cumulated ammonia emissions caused approximately 60% of the ND by ammonia and is also referred to as the "death by a thousand cuts-phenomenon". This shows the need for further generic measures (Cools et al., 2015, p. 58), but these are not clearly added in the Flemish PAN. In a Q&A session in December 2020 in the Flemish Parliament about these cumulative effects, the following reasoning was applied by the Minister Demir: "we have all current emissions included in the background deposition and only have to assess if new requested activities have significant impact or not" (Vlaams Parlement, 2020). A similar reasoning can be found in the Dutch PAN (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 40).

In theory this is a fair point because the background ND on regional level of Flanders is modelled, measured and/or calculated with a rather acceptable certainty of 30% (see also attachment 2 FUNVLOPS 1&2). But, still, many small polluters can continue with their Business as Usual, creating 60% of the problem! This is a political choice that could be driven by the "complex political context" as TAUW states in its midterm report (Bekker & Heijligers, 2018, p. 39). We argue that this is rather driven by avoidance of resistance by the big number of farms. We will reflect further on this political trade-off in section 4.4.1 and in the discussion in section 5.

4.2.2 Uncertainties in the prognosis and downward ND trend

New ND room is not only created by the PAN source measures. In the Dutch and Flemish PAN, the downward trend of ND as result of current policies also counts for a part of the ND room that can partly be used for new activities. Emission reductions, cleaner technologies, and cleaner transportation vehicles are examples of the developments that create the downward trend. Both the Dutch and Flemish PAN assume a continuing downward trend of ND in the next decennia and use this

[7] The impact score of an exploitation or activity is determined by comparing its highest ND value for a habitat-cell with the CL for that habitat type. So if only 1 habitat-cell of a habitat has an increased ND level due to the exploitation or activity then this defines the impact score, the red, orange or green color and its permitting regime.

assumption to justify new economic development without jeopardizing the good conservation status of Natura 2000 habitats (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, pp. 21, 22; Schauvliege, 2016a, pp. 14, 20).

In the Dutch PAN case, these developments are explicitly quantified based on an economic development of 2,5% per year and added in the ND prognosis (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, pp. 28, 95, 96). In Flanders, the so-called Business as Usual (BAU) scenario represents the development of current policies and its influence on the ND levels, but this is not quantified further in the studied documents. Table 4.2 shows the uncertainties related to the prognosis and autonomous ND trend.

In the Dutch PAN case, uncertainties in the ND prognosis mainly relate to the future livestock size (see attachment 1 UNDP 1-4). PBL estimates that this size could grow with 10 to 30% because of the planned ending of milk quota (Folkert et al., 2014, p. 25). Two other uncertainties with regards to the ND prognosis concern the "stagnation effect" (UNDP3) and the "dormant ND room effect" (UNDP4). The stagnation in business development was caused by the pre-PAN situation with a locked permitting system because of the stringent Nature Protection Law 1998. This stagnation effect would be released with the start of the PAN causing a flood of permit request by farmers that would catch up with their stagnated business development (Doekes, Nijboer, & Bekker, 2015b, p. 33). The dormant ND room effect is the ND room which was permitted in the past but never really filled with activities, mostly livestock capacity. Hence the "dormant" room can be filled without being visible through reporting or permitting procedures. It was stated however (see attachment 1 UNDP4) that these effects are part of the prognosis (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b, p. 64).

A remarkable statement in the intermediate PAN report 2018 by Tauw relates to the prognosis for 2030. It appeared that the total ammonia-emissions reduction in 2030 will be 5.7 million kg instead of 5.0 million kg because "the stables were less clean in 2014 than anticipated in the prognosis" (Bekker & Heijligers, 2018, p. 43). In this statement however, Tauw assumes that the ammonia emission levels in 2030 will be reached. This is rather uncertain because of the likely growing size of the livestock and the likely effectiveness of the PAN source measures. It would have been more appropriate that Tauw would have concluded that the prognosis was too optimistic, and less ND room was available for new activities than planned in the Dutch PAN (see attachment 1 US7).

The RIVM monitoring report 2018 of the Dutch PAN showed not only that the size of the livestock increased, but also the productivity per animal. The food that was used created more ammonia emissions, and the export of manure was lower than reported (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2019, p. 41). Further, the emissions caused by fertilizer were missed in the ND prognosis. The studied documents do not clearly quantify these additional ND causes, but it can be concluded that all these uncertainties created an overestimation of the available ND room for new activities (see attachment 1 US4).

For the Flemish PAN case, the prognosis in NOx and NH3 emissions are briefly but clearly explained in observation FUNDP1 in attachment 2 (Schauvliege, 2016a, pp. 13, 14), but without mentioning any degree of uncertainty. The graph on p. 14 of (Schauvliege, 2016a) shows that the decreasing ND trend is mainly the result of cleaner transportation vehicles. Additional elements of the decreasing trend are the expected relocation of farms and the 3-4% of farms, on a yearly basis, that stop their activities (see attachment 2 FUNDP4). Again, the origin of these prognoses is unclear and not mentioned in the studied documents.

The Flemish ND prognosis heavily depends on the size of livestock. Schauvliege states in her concept nota that the Business As Usual scenario is based on a stable livestock, and that the amount of animals kept in low-emission stables will increase (Schauvliege, 2016a, p. 16). Uncertainties, and the basis for this assumption, are not mentioned. Schauvliege's concept nota describes that the prognosis is based on the emission reducing measures that "the sectors take as influence of policies"(Schauvliege, 2016a, p. 15). No clear measures are described or quantified. The qualification "under the influence of policies" suggests a degree of voluntary cooperation which would be a weak point with regards to the effectiveness (see attachment 2 FUNDP2).

In the financial plan in the Natura 2000 program, it is stated on page 51/52 that "the Natura2000 plan is a dynamic process depending on various juridical, political and institutional factors" and it is based on the "best available information at this moment" (Agentschap voor Natuur en Bos (ANB), 2017a, pp. 51, 52). This remark suggests uncertainties, but this is not further discussed, clarified or quantified (see attachment 2 FUNDP3).

The Flemish PAN prognosis assumes that 54 "red" farms will have been stopped by 2030. Of the long list of 498 "orange" farms, 3-4% is expected to stop on a yearly basis and in total 30% are expected to relocate (KENTER, 2018, pp. 24, 25). The origin of these figures is unclear, but it is estimated that this will reduce ND by 26% by the orange category alone (see attachment 2 FUNDP3).

Finally, ammonia emission from manure was not considered in the EMAV (Emission Model Ammoniak Vlaanderen) 1.0 model or in the ND prognosis. This is corrected in the EMAV 2.0 model but still data is lacking about individual exploitations (see attachment 2 FUNDC 2 & 3).

4.2.3 Uncertainties related to the Natura 2000 area analysis and recovery measures

Both the Dutch and the Flemish PAN include a set of recovery measures to support the resilience of Natura 2000 habitats against the environmental pressure caused by ND. This list of possible recovery measures shows a large variety of measures from rather simple Nitrogen removing activities such as grazing, mowing and sod cutting, to complex eco-hydraulical projects (De Keersmaeker et al., 2018). The recovery measures have important uncertainties. Many recovery measures, such as eco-hydraulical measures, depend on the voluntary cooperation of landowners. When the willingness and support is lacking, this causes delays in the execution, as objected by Natuurpunt during the public consultation of the Natura 2000 program in 2017 (Agentschap voor Natuur en Bos (ANB), 2017b, p. 169) (see attachment 2 FUNRM2). And even if the measures are executed in time, it is still uncertain if the measures will have the desired effects. Many measures are not proven in practice and others take a long time to take effect. Recovery measures can even have adverse effects or compete with other recovery measures (De Keersmaeker et al., 2018). De Keersmaeker et al. give as example the uncertainties because of adverse effects of recovery measures and the competition between acidification measures and eutrophication measures (De Keersmaeker et al., 2018, p. 55). Other scientist, like Arnold van den Burg qualify the recovery measures as “symptom-control” rather than real recovery (Van den Burg, 2019, p. 115).

In the Dutch PAN, a total of 1977 recovery measures for all sites and of all types were defined, of which 310 are clustered into complex recovery projects (PAS-bureau, 2019, p. 20). PBL stated in their assessment report in 2014 that this part of the PAN was very ambitious and depends on the willingness of landowners to cooperate in certain measures (Folkert et al., 2014, p. 65). Hence, the recovery measures had a large planning and achievability uncertainty.

Recovery measures in the Flemish PAN are described in detail by De Keersmaeker et al., but the wording “uncertainty” is only used twice (De Keersmaeker et al., 2018). Uncertainties however can be derived from the descriptions of the possible positive and negative effects per recovery measure (see attachment 2 FTRO-RM1 & FUNRM4) and the classification of the measures as “proven”, “rule of thumb”, or “hypothetical”. The latter are most uncertain, the “proven” measures rather certain. This same classification is used in the Dutch PAN (see attachment 2 FUNRM8). Since the recovery measures are similar to the Dutch recovery measures, it can be assumed that also the uncertainties are comparable. De Keersmaeker et al. emphasize in their report that the effect of recovery measures will not last if the ND is not reduced simultaneously (De Keersmaeker et al., 2018, p. 56). Natuurpunt and Bond Beter Leefmilieu point to the lack of funding as cause of uncertainty in the recovery measures (Agentschap voor Natuur en Bos (ANB), 2017b, p. 169) and a brief study of area analysis report Zandig Vlaanderen Oost shows > 50% of the area is owned by private landowners from whom voluntary cooperation is needed (Agentschap voor Natuur en Bos, 2022). This example (see also attachment 2 FUNRM9) implies uncertainty in the execution of recovery and dependency on the voluntary cooperation of farmers and landowners.
A remarkable difference between the Dutch and Flemish PAN is that the execution of the recovery measures in the Flemish PAN was planned to be operationalized by the Natura 2000 management plans. A brief study and interview with H. Van de Wiele [8] (personal communication, May 18th, 2022) showed that the implementation of recovery measures is integrated into the execution of the Natura2000 plans. The ABN Monitoring report 2018 shows quantified results about conservation activities but the progress reporting of the recovery measures is largely missing (Agentschap voor Natuur en Bos (ANB), 2018). See also section 4.3.2.

The recovery measures are important pre-conditions in the Natura 2000 area analysis (gebiedsanalysis) that were conducted in preparation of the Dutch and Flemish PAN. The area analysis was conducted and reported by ecologists and competent teams with knowledge about the ecosystems and local circumstances (see attachments 1 UR1, UGA4 and attachment 2 FUNGA7&8). In the Dutch PAN, the area analysis reports played an important role in the determination of the available ND room per area. In the Flemish PAN, the area analysis is merely conducted as basis for potential useful recovery measures.

[8] Hannelore Van De Wiel is Natura 2000 area coordinator region west for the Agentschap Natuur en Bos, Coordinator Gebiedsgerichte werking regio west and involved in development of Natura 2000 Management plans and alignment with local conservation goals and recovery measures

Natura 2000 area analysis and the Precautionary Principle

The Pre-PAN Assessment (Opnametoets) of the Natura 2000 area analysis took place by OBN (Ontwikkeling & Beheer Natuurkwaliteit) in the time period February – July 2013. The objective of this pre-PAN Assessment was to check the ecological basis of the area analysis and feasibility of the recovery measures. All areas passed the Pe-PAN Asessment and were added to the Dutch PAN. Based on the condition that recovery measures would be fully executed and successful, an amount of ND room was defined per area and added to AERIUS. The availability of ND room is remarkable having in mind the bad and worsening conservation status in many areas caused by the decades of high ND levels. A few observations in the Dutch case study indicate how this pre-PAN assessment was conducted:

(1) The directive instructions and hard deadline towards the area teams in the "Notitie afronding gebiedsuitwerkingen t.b.v. opname in PAS, February 14th 2013" (De Peuter, 2013) illustrate the pressure on the Area teams to advise positively in their conclusions;

(2) In attachment 2 of the same document, a text to 'help' the authors to write the concluding text is pre-scribed. According to the notice the text was recommended to have all conclusions written a clear and comparable way. It gives a strong indication however that this text was crucial for the legal robustness and to exclude any reasonable doubt.

(3) Another observation shows the circumstances in which the Natura 2000 have been signed off for approval during the pre-PAN Assessment: in the NRC article "Stikstof akkoord moest en zou er komen" on dec 27th 2019 (KAMER about the rewriting of reports and 'forced sign-off sessions' (KAMERSTUKKEN II Aanhangsel 1744, 2020).

Very little data can be found about the external review of the Natura 2000 area analysis. This external review was strongly recommended by the Commission MER in the assessment recommendations that were added to Environmental Effects in May 2015. The missing external review was used as argument by Greenpeace to fight the permit for a new Power Plant on the Dutch Maasvlakte in 2016 after a 5 year lasting procedure. Greenpeace argued that without this review the Natura 2000 area analysis was not sound to legitimize the spending of ND room. This argument failed in the final Court of State ruling on January 27th, 2016, because there was no reasonable doubt about the soundness of the area analysis (Raad van State, 2016) .

The observations described above (see also attachment 1 UGA7) illustrate how the Natura 2000 area analysis were twisted juridically in order to withstand the "without reasonable doubt"-test in the court room and legitimize the ND room. This can be considered a clear example of violation of the Precautionary Principle.

Uncertainties in the recovery measures show an important weakness in the Dutch PAN: The acceptable CL levels for the particular Natura 2000 sites are based on recovery measures that, as mentioned before, have a challenging execution schedule and depend on the willingness of landowners to cooperate. Further, many recovery measures are not proven in practice while the execution of the recovery measures are important pre-conditions for the ND room balance. The execution of recovery measures that are ineffective or even contra-productive will put the conservation status at risk even further, while the main objective of the Dutch PAN is to, at least, stop further deterioration of habitats due to ND (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2017, p. 21). Remarkably, the Environmental Effects Report part II (Appropriate Assessment) of the Dutch PAN leaves no reason for doubt: "Op basis van de passende beoordeling (gebiedsanalyses en generiek deel) kan worden uitgesloten dat de natuurlijke kenmerken van enig Natura 2000-gebied worden aangetast en de instandhoudingsdoelen van het gebied" ((Doekes et al., 2015b, pp. 8, 9). However, this report states that the area analysis itself is not part of the Appropriate Assessment and in their assessment recommendation, the Commission MER recommends to conduct a "well documented external review on all area analysis during the first PAN stage" (Commissie voor de Milieueffectrapportage, 2015, p. 13). This suggests at least that the area analysis need a closer review. The area analysis can be considered the "appropriate assessments on area level" (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b, p. 25) and the basis for the determination of the available ND room per Natura2000 site. The area analysis can be considered the ecological backbone of the PAN. From the perspective of the precautionary principle, it can be argued that the external review should therefore have been conducted prior to the start of the PAN and not during the first PAN stage when the ND room is already spent (see attachment 1 UGA 2 & 3).

Observation UGA1 in attachment 1 describes the pre-PAN assessment ('opname-toets') of the area analysis to assess their ecological soundness. Little information is available about the way this assessment was conducted, by who and what criteria were used (see also the textbox).

In the Flemish PAN, the 38 Natura 2000 area analysis were conducted and reported between 2016 and 2018. Each report consists of a general section and an area-specific section. The area-specific part gives a motivated recommendation for recovery measures at (sub)habitat level.

In the general section, which is common for all area reports, an important statement explains that the report is based on a limited landscape-ecological system analysis (see attachment 2 FUNGA1, 6 & 7). The knowledge, expertise and data are fragmented, and the available monitoring reports cover only parts of the area (Decleer & Vandekerkhove, 2018, p. 8). This statement shows that the best available information was used but that many knowledge gaps exist in the analysis. Therefore, the authors emphasize that the aim of the analysis is to assess and recommend which recovery measure ***can*** be used for each habitat part, but that the actual choice if and how a recovery measure will be implemented, must be taken at the lowest level in the management plan, with consideration of the local conservation goals (Decleer & Vandekerkhove, 2018, pp. 8, 9).

The interview with H. Van de Wiele (personal communication, May 18th, 2022) about the incorporation of recovery measures into the Natura 2000 Management Plans clarifies how this integration process works. Before the recommendations per area were finalized in the report, the local possibilities and needs were discussed with local experts. For drastic measures, like hydrological and landscape projects, and extensive planning phase was started to find consensus with all local stakeholders about the implementation of the measures within the local constraints. Only when the minimum required recovery measures were not achieved by consensus, a certain degree of enforcement was used. In many cases however more than the minimum required recovery measures could be achieved through careful planning and involving all stakeholders (personal communication, May 18th, 2022). This description shows that proper integration of recovery measures into the Natura 2000 plans is time consuming, needs negotiation and creativity, and is depending on participation of local stakeholders.

4.2.4 Uncertainties in measurements, tools, and models: AERIUS and VLOPS-IFDM

Uncertainties related to calculation and modelling of ND caused a lot of discussion, in particular in the Netherlands (Munnichs & De Vriend, 2018). The main tool in the Dutch PAN is the AERIUS calculation and monitoring tool. AERIUS is developed by the Dutch National Institute for Public Health and Environment (Rijksinstituut voor Volksgezondheid en Milieu (RIVM)), and considered state of the art for the purpose of modelling and calculating of ND (see attachment 1 UAE7 – Development). The calculation module of AERIUS is the OPS (Operationeel Prioritaire Stoffen)-module. OPS is also the main calculation module for the Flemish modelling and calculation tool VLOPS (Vlaamse OPS). Besides AERIUS and VLOPS, two other models are important in the PAN cases: NEMA (National Emission Model for Agriculture) for ammonia emission modelling in the Dutch PAN and the EMAV (Emission Model Ammoniak Vlaanderen) for the Flemish PAN. Table 4.2 shows the uncertainties in the above-mentioned models.

Uncertainties concerning the AERIUS tool, are mainly caused by the limited amount of ND measurements to validate the AERIUS model and calculations. ND measurements are expensive, complex, and only a limited number of ND measurement locations is available to provide data for the validation (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015a, p. 10). The uncertainties in AERIUS calculations are reported to be 30% at national scale but can be as high as 70% on a local scale (Folkert et al., 2014, p. 78) (see attachment 1 UAE1 & UNDM1).

The uncertainties concerning the VLOPS-IFDM ND calculation and modelling tool used in the Flemish PAN, are extensively described by Lefebre & Deutsch. VLOPS calculates emissions and deposition of acidifying components with a geographical resolution of 1 x 1 km. It includes cross border transfers. The IFDM (Immissie Frequentie Distributie Model) uses emission source data to calculate and model the dispersion of emissions. The combination of VLOPS-IFDM is validated and appears to be a valuable tool in the ND modelling and calculations because they are complementary (Lefebre & Deutsch, 2015, pp. 2, 132). However, Lefebre & Deutsch mention uncertainties of up to 70% at local scale (Lefebre & Deutsch, 2015, p. 130), equivalent to the uncertainties of OPS. Lefebre & Deutsch therefore emphasize to take these uncertainties into consideration when the VLOPS-IFDM results are compared with the CL at a local level (Lefebre & Deutsch, 2015, p. 146), see also attachment 2 FUNVLOPS1, 2 & 3. Similar descriptions about the VLOPS uncertainties at macrolevel and microlevel are reported by Cools et al. in 2015 (Cools et al., 2015, p. 58). Uncertainties of the IFDM model are mainly caused by the lack of exact emission parameters like flow, height, and temperature (Lefebre & Deutsch, 2015, p. 147).

The third key model related to the Flemish PAN is EMAV (Emissie Model Ammoniak Vlaanderen) that calculates ammonia emissions using the number of animals, stable type, and the applied emission reduction installations (see attachment 2

FUNDC3). The input data for EMAV show important knowledge gaps: the source parameters emission height, flow and temperature are not known and therefore assumptions are made and the emissions caused during manure spreading are not incorporated (Cools et al., 2015, pp. 46, 48).

In summary, we can conclude that the uncertainties in the applied models and calculations are known and considerable. The strong focus on these uncertainties is put in perspective by nitrogen expert J.W. Erisman in an expert debate in the Dutch parliament on February 23th 2022. Erisman argues that uncertainties play a limited role in times, like today, when the exceedance of the critical load is so large and that the available knowledge in studies and measurement data is enough to support the policies. (Erisman, 2022). With this statement, Erisman counters the criticism by the farmers coalition about using the modelling data as basis for the PAN because the uncertainty levels were too high.

4.2.5 Uncertainties in the critical load and the balance of ND room

In the Dutch and Flemish PAN cases, ND room is created for economic development and to avoid a complete permitting stop for economic developments. See also 4.2.1 and 4.2.2. and attachments 1 UNDP8 and attachment 2 FLF3. The uncertainties on the ND room creation side of the balance was discussed in the previous paragraphs. Uncertainties in the consumption of ND room have less attention in the studied literature. Some observations however, strongly suggest that little uncertainty exists about the release of permits for additional agricultural activities: The Dutch case study shows in observation UNDC4 in attachment 1 of the Tauw 2018 intermediate report that the available ND Room is allocated swiftly in the first years of the Dutch PAN stage (Bekker & Heijligers, 2018, pp. 36-38 & 48, 55). This resulted in the lowering of the threshold for activity reporting from 1 mol/ha/yr to 0.05 mol/ha/yr on 62 of the 118 Natura 2000 sites [9]. The numbers in the monitoring reports suggest that the bookkeeping in AERIUS of the used versus available ND room is precise and accurate. However, some critical remarks can be made related to the bookkeeping and “ND leaking” (the ND that is caused but does not appear in the books). First, it should be considered that ND leakage is caused by not or incorrectly reporting of ND causing activities that are below the permitting threshold of 1 mol/ha/yr. Below this threshold a reporting-obligation (meldigsplicht) is applicable but it is unclear if and how this obligation is enforced. This consideration was also raised during the public review (terinzagelegging) of the Dutch PAN in 2015 (Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b, p. 33). See also the “death by a thousand cuts phenomenon” in par 4.2.1, and attachments 1 UNDC4, and attachment 2 FUNDC1 & FUNDC3. Secondly, as mentioned during an interview with M. van Lighten [10] it is difficult to tell by how much the emission prediction for new activities in permit requests is downplayed by specialist-consultants that perform the initial AERIUS calculations for permit requests (personal communication, May 11th, 2022). These alleged ND leaking causes were not further investigated but it can be expected that these exist while no ND room was planned for it.

In the Flemish PAN case, the permit procedure includes an individual appropriate assessment for each permit request. In the interview with D. De Hemptinne [11] this shows to be a strong point because it creates an additional check on the ND room consumption for new activities (personal communication, June 3rd and 9th, 2022). Little attention however is paid in the Flemish PAN to the ammonia emissions by manure spreading (Schoukens, 2021, pp. 31, 32). See also attachment 2 FTROND6, FUNDC2, FUNDC3. The old practice in Flanders to spread manure by farmers as needed and without limitations seems to be well tolerated (Stikken in de stikstof, 2022, p. 13). This is remarkable considering the extensive discussions that took place in The Netherlands about the reduction of emissions from manure (see attachment 1 US4, UNDP1 & UNDP2).

[9] The Dutch PAN prescribes that this threshold must be lowered from 1 mol/ha/yr to 0.05 mol/ha/yr when at least 1 of the hexagons of the habitat exceeds 95% of the available ND room.

[10] M. van Ligten is ecologist at the Rijksuitvoeringsdienst Utrecht, and consults in environmental permit request

[11] D. De Hemptinne of the Agentschap Natuur en Bos applies the appropriate assessment for Environmental permits in the province of East Flanders.

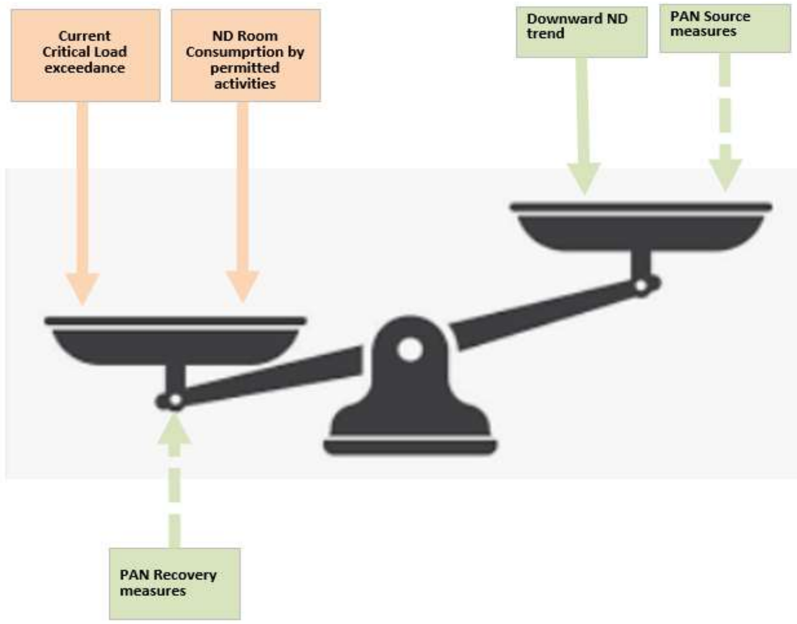

Figure 4.5: Illustration of the out-of-balance situation in the Dutch and Flemish PAN. Current critical Load exceedance and the steady consumption of ND room by new permitted activities weighs heavily on the balance. Counterweight is created by the downward ND trend and the ND Room creation by PAN measures. This counterweight is relatively small with 10 – 15% in the time-period 2014 – 2030 and has many uncertainties. The habitat supporting recovery measures are difficult to implement and the effects are mostly long term and uncertain.

Figure 4.5 illustrates how the uncertainties in ND room creation and ND consumption influence the balance in ND room [12] . Observation CL1 in attachment 1 shows that with a planned ND reduction of 10-15% between 2015 and 2030 in the Dutch PAN (Doekes et al., 2015a, p. 39 & 59), the CL will still be exceeded on 55-70% of the Natura 2000 area in 2030. This shows a very limited ambition to lower the ND levels. Besides, the uncertainties in the PAN source measures and downward ND trend tend to result in *over*-estimation of the created ND room (see par 4.2.3). The high pressure to unlock the permitting system, and the high amount of permit requests illustrate that the ND room consumption is likely *under*-estimated (see attachment 1 UNDP1 & UNDC3 - Development). These observation's, and the TAUW 2018 report (Bekker & Heijligers, 2018, p. 8) illustrate the low ambition level of 15% ND reduction in 15 years in the Netherlands.

The Flemish PAN, as part of the Natura2000 program, aims to accelerate the downward ND trend on N2000 area's but without using the CL[13] as a "hard target" (see attachment 2 FCL3). This suggests that the policymakers accepted that the CL will not be reached with the PAN measures, which is a weak point if nature conservation must be balanced with economic development. As discussed above, the Flemish PAN is less transparent about uncertainties in the downward ND trend and the source measures. It can be expected however, that, like in the Dutch PAN, the creation of ND room is over-estimated and ND consumption underestimated. The ND reduction ambition in the Flemish PAN is even lower than in the Dutch PAN with only 10% in 15 years (Schauvliege, 2016a, p. 16). See also attachment 2 FUNDP2.

The result of the over-estimation of ND creation and under-estimation of the ND consumption will result in the unbalance shown in Fig 4.5. The recovery measures that are meant to support habitats resilience against high ND levels, have many uncertainties as well and it is highly unlikely that these can level the unbalance. The conclusion that follows from the previous paragraphs is that in both the Dutch and Flemish PAN the low PAN ambition level, in combination with uncertainties in the ND creation, will lead to further deterioration of Natura 2000 habitats. In other words: failure of the PAN objectives.

[12] The term ND room is not explicitly used in the Flemish PAN. The Natura 2000 plan by ANB suggests the "development of a user-friendly tool to monitor the available "ND development room"(Agentschap voor Natuur en Bos (ANB), 2017a, p. 70). This is a rare reference to the ND Room concept in the Flemish PAN

[13] The CL definition and values for the Dutch and Flemish PAN are similar and accepted as best practice (see also attachment 2 FUNGA4 and FCL1).

4.2.6 Legal (un)certainties: "It is harsh, but it is the law"

Many parties had a stake in the Dutch and Flemish PAN. This is illustrated by the 635 submitted perspectives on the Dutch PAN, and 54 notices of objections by stakeholders in the Flemish PAN (Agentschap voor Natuur en Bos (ANB), 2017b; Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015b, p. 2). The Dutch government aimed for a 'robust' approach with little or no changes (Folkert et al., 2014, p. 44) to avoid further stagnation of the permitting process. This stagnation became a problem under the Nature protection law 1998 (see attachment 1 MLA5, DUL2, DLF4) and drove the efforts to set-up the PAN. The Flemish government did understand that a degree of legal uncertainty was characteristic for the approach (see attachment 2 FTROND6) (Vlaams Parlement, 2015, p. 17) and that a lot depended on the appropriate assessment of the individual permit requests (Vlaams Parlement, 2018, p. 1).

In the Netherlands, the PBL reported several legal uncertainties in the Dutch PAN (see attachment 1 DLF2, DUL 1 & 3). The lack of legal enforceability and dependency on voluntary cooperation by the farmers created uncertainty about the application of the source and recovery measures (Folkert et al., 2014, p. 57). Besides, PBL stated that the PAN is unclear about the Critical Load levels for habitats: Is it an obligation, an objective, or a target? (Folkert et al., 2014, pp. 11, 12).

The legal uncertainties in the Dutch and Flemish PAN case are very well documented by Schoukens & Larmuseau. From this document we can learn how various legal cases occurred during the preliminary stage of the Flemish PAN and these cases influenced the way the Flemish PAN developed. The Sweetman case (about impact of activities on conservations goals) and the Orleans case (about anticipation on future positive effects of measures), led to a constant concern among politicians, scientists, and farmers about the difficult legal balancing act (Schoukens & Larmuseau, 2017, p. 256). These law cases, as well as (1) the answer by the European Court of Justice courts to prejustical questions of 7 nov 2018 regarding the Dutch PAN regulation, (2) the d'Oultremont judgement about the plan-MER, and (3) the ruling by the Dutch Council of State in May 2019, are examples of cases to which the Flemish government anticipated (see also attachment 2 FTROND6).

Another source for legal uncertainty in the Flemish PAN is the methodology of Search Area's [14] and the 'jumpers' phenomenon. During the 'placement' of habitats within the Search Area's, the designation of parts of the Search Area becomes clear: Either it is designated as habitat and will be protected, or it becomes free area in which other activities can be developed. During the designation of habitats, or during adaptations in the permitting framework, the neighboring exploitations can "jump" from a lower into a higher significance category or the other way around (Schauvliege, 2016a, p. 6). This is inherent to the Search Area methodology but considered as "legal quicksand" by some critical politicians (see attachment 2 FLF 11/12 & FTRO-SA4).

From nature protection perspective the Search Area methodology gives the certainty that conservation goals can be met as much as possible because the whole Search Area is considered protected area until the placement of habitats within the search area is finalized. Landowners and farmers however, argue that this approach causes legal uncertainty and hampers economic development (Vlaams Parlement, 2015, p. 13).

The observations described above show that there is a dilemma between the adaptability of the PAN and its legal certainty or robustness. This dilemma appears to be typical for instruments for environmental governance (Squintani & van Rijswick, 2016). The PAN measures must be adaptable to new knowledge and adjustable as monitoring results become clear. But adaptability, for instance by making measures more stringent or lowering emission thresholds, can have impact on neighboring businesses. See also 4.4 Trade-offs.

In the earlier mentioned legal analysis of the PAN (Schoukens & Larmuseau, 2017), Schoukens & Larmuseau conclude that the law cases showed that the Habitat Directive gives little or no margin for authorities to *create* development room when a Natura 2000 area is already overloaded. "It is harsh, but it is the law" (Schoukens & Larmuseau, 2017, p. 131).

4.2.6 Partial conclusion about uncertainties in the Dutch and Flemish PAN

With the case study results about the uncertainties in the Dutch and Flemish PAN cases we can revisit the first research questions Answers to research question 1:

(1) How are scientific uncertainties regarding Nitrogen deposition and its effects on Natura 2000 areas dealt with in the Dutch and Flemish PAN?

[14] (Agentschap voor Natuur en Bos (ANB), 2015, p. 9) describes Search Area's as areas with a perimeter in which the to be protected habitat or species will be 'placed' in the most favorable way to obtain the conservation status. The size of the Search Area is determined by the degree in which a conservation goal is yet to be realized.

Different sets of uncertainties play a role in the Dutch and Flemish PAN. In the Dutch PAN, much attention is paid to uncertainties in the ND calculation models. These have uncertainty levels of 30% to 70%, which is considered high but still acceptable considering the high exceedance levels of the CL at many Natura 2000 habitats. The uncertainties in the effectiveness of source measures and recovery measures are known but not backed up by additional measures. Uncertainties in the prognosis of the downward ND trend are reported in some documents but again without clear back-up measures in the case that the downward ND trend would not materialize.

The Flemish PAN is less explicit about uncertainties, but the case study shows similar uncertainties for source measures, recovery measures, and the downward ND trend in the Flemish PAN than in the Dutch PAN. Besides, in the Flemish PAN we also miss the back-up measures.

The source measures, recovery measures, and the downward ND trend, should all create new EUS-ND room and legitimize new ND by economic activities. But because of high uncertainties in and overestimating of the positive effects of the measures and the ND trend, creation of ND room is rather “wishful thinking”. On the ND-consumption side of the EUS model (new permit requests for additional ND), little uncertainty existed because of the drive for business development. Besides, the EUS-ND consumption shows to be underestimated.

The overestimation of the effects of source and recovery measures, the optimistic picture of the downward ND trend and the underestimation of new ND, resulted in a continued imbalance between the creation and consumption of EUS ND. This imbalance must be placed against the background of low ambition levels to reduce the ND in the Dutch and Flemish PAN.

4.3 Monitor-Learn-Adapt (MLA)-principle in the Dutch and Flemish PAN cases (Research Question 3)

Uncertainties as described in section 4.2 are inherent to a programmatic Approach like the PAN. The monitoring program with learning and adaptation are therefore crucial elements to gather valuable data, reduce uncertainties, and increase the effectiveness of the Programmatic Approach (see MLA principle in section 2 Theoretical Framework). Both the Dutch and Flemish PAN acknowledged the importance of monitoring and adjustments as monitoring results and new knowledge becomes available (Agentschap voor Natuur en Bos (ANB), 2017a, p. 20; Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2015, p. par. 6.1 & 6.2.1; Schauvliege, 2016a, pp. 23, 25). In the next paragraphs the findings about the MLA-principle in the Dutch and Flemish PAN cases are discussed respectively.

4.3.1 The Monitor-Learn-Adapt (MLA)-principle in the Dutch PAN

The Dutch PAN attachment 6 and 7 describe the extensive monitoring and adjustments plan of the Dutch PAN (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2015). See also attachment 1 MLA8. The frequency of reporting, the objectives, and the report contents are listed. The PAS-bureau was responsible for the coordination of the reporting. The RIVM was responsible for the monitoring of ND. Paragraph 6.2.5. of the PAN describes the monitoring and adjustment of the available ND room. During the case study it showed that the monitoring reports are freely and easily available and contained the required information. This can be considered a strength in the Dutch PAN.
A weak point is the ecological monitoring of the Natura 2000 areas. The monitoring methodology using "process-indicators (PI)"[15] was not sufficiently defined and a "zero reference point” was not available (Folkert et al., 2014, pp. 68, 69). This introduces uncertainty and shows that an important MLA-element of the PAN, "Monitoring of ecological effects", was not in place.

[15] An approach with “process indicators (PI)” is developed in the Dutch PAN to monitor the effects of the recovery measures. The PI’s give intermediate ‘early’ results about the aimed ecological recovery before the recovery can actually be measured in a reliable way. Examples of PI-types are remote sensing, abiotic measurements, vegetations, and the use of indicator species (see attachment 1 MLA17). The analysis of PI’s needs local expertise and depends on a certain response-time after completion of the recovery measure. In total, 3561 PI’s for the 1977 recovery measures in the 118 N2000 sites have been set-up.

Monitoring-Learn-Adapt (MLA)-principle in the Dutch PAN	
ELEMENT	**FINDINGS**
Monitor	• MLA-principle depends heavily on the AERIUS model and calculations (MLA3, MLA4) even though AERIUS has uncertainty levels of 30% (UAE1) and the ND measurements to validate AERIUS are limited (UNDC3) • Monitoring methods for ecological processes is not established: no zero-reference measurements and process-indicators not well defined (MLA4) • Clear and abundant attention for the monitoring plan (PAN attachment 7) and adaptation (PAN attachment 6) (MLA8)
Learn	• Additional research on the ammonia concentration calculated by AERIUS versus the emissions measurements resulting in adjustments (MLA12 - Development) • Developments in the AERIUS tool with many reviews (TNO, Aarhus University resulting in updates and improvements Development and application of local expertise knowledge about the effects of recovery measures (MLA17) • Review and capturing of learnings about recovery measures in “Herstelstrategieen-report”
Adapt	• Lack of back-up measures to adapt the PAN • Over-simplification of “adaptation” by using metaphors “hand-on-the-tap", "pulse-check”, and “control buttons”. • Adjustment of the threshold from 1 to 0.05 mol/ha/yr in 62 Natura 2000 area’s in september 2017

Table 4.3: Overview of the findings about the MLA-principle in the Dutch PAN

The development of the ecological monitoring showed that after 3 years, in 2018, 90% (3171) of the 3516 PI was defined but only 0,5% was monitored (PAS-bureau, 2019, pp. 30-32). The main reason for this backlog in monitoring was that it depended on the progress and effects of the recovery measures. In March 2020, 649 of the 1977 recovery measures were completed and together these were represented by 1665 PI’s. But even with the PIs in place, a reliable assessment of the effectiveness of the completed recovery can take years (BIJ12, 2021, pp. 31, 32). See also attachment 1 MLA17. This illustrates the complexity and time-consuming character of ecological monitoring. This complexity of ecological monitoring, which is an important part of the PAN, contrasts sharply with some metaphors used in the Dutch PAN: the “hand-on-the-tap-principle” for permitting new activities, the use of “control-buttons” for policy adjustments, and “pulse-checks” to monitor ecological status (Bekker & Heijligers, 2018, p. 28) during field visits are all oversimplifying the monitor-and-adapting process and create a false sense of control in the ND problem. This is a weak point in the Dutch PAN. See attachment 1 MLA1, 5 & 18.

The development of recovery-PIs with participation of local expertise fits well in the MLA-principle as learning element. These learnings are captured in the report by Bal et al. in their report on Recovery Strategies for nitrogen sensitive habitats after a review by an international commission (Bal et al., 2014). This shows an active approach towards closing of the knowledge gaps and this is a strong MLA-element. See also Attachment 1 MLA22. Another learning element in the Dutch PAN is the research performed to close the gap between modelled ammonia concentrations and ammonia emission measurements. This research demonstrated how the chemical composition of the atmosphere and weather circumstances influence the ammonia concentration (Rijksinstituut voor Volksgezondheid en Milieu (RIVM), 2019, p. 30) which was a missing piece of knowledge in the modelling. Further, the reviews by the Aarhus University, TNO, and M. Sutton et al. show that the AERIUS tool is state-of-the-art and the best available tool for ND modelling which is a strong MLA element (RIVM, 2022; Sutton et al., 2015). The AERIUS tool has had multiple updates which shows that the tool was adapted as new knowledge became available: more accurate data, improved models and a more user-friendly interface (see attachment 1 UAE6 & UAE7).

A clear adaptation in the Dutch PAN can be found in observation UNDC4 in attachment 1. On September 1st, the threshold for permit-free activities became stricter on 62 of the 118 the Natura 2000 areas (Bekker & Heijligers, 2018, p. 48). This adaptation to change this threshold from 1 to 0.05 mol/ha/yr was foreseen in the Dutch PAN for the case that the AERIUS Monitoring tool showed that the ND room on one of the habitat cells in the Natura 2000 area was consumed for 95%. The PAN program itself was adapted twice in 2017 as result of the actualization of AERIUS, the updated ND calculations, and the updated available ND room per area.

The weakest point in the MLA principle of the Dutch PAN is the lack of additional measures (also called “back-up measures”) to adjust the plan in the case of set-backs like disappointing results in emission reduction. The Dutch PAN planned to foresee a list of back-up measures during the first PAN stage (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2015, p. par 6.3.2) but the Tauw intermediate report in 2018 showed little progress on this essential element. The Tauw report states that exercise to establish the back-up measures was done "carefully in a politically sensitive context" (Bekker & Heijligers, 2018, p. 39). This statement can be read as “little support among stakeholders to provide room for adaptation”. Hence, the Dutch PAN case shows monitoring, learning, but no adaptation (see also attachment 1 MLA 14 & 22).

Hand-on-the-tap metaphor and "being in control"

In the Dutch PAN, the metaphor "hand-on-the-tap" is used to explain the concept of the adaptation in the PAN. Proper functioning of this controlling-principle however, requires a control loop (feedback or feed forward) with a set-point, a sensor to measure the actual flow, a comparing unit (AERIUS has partly this function) to compare actual with desired flow and an acting device to adapt: opening or closing of the tap as required to reach the set-point. Using this metaphor in the PAN case seems to be an over-simplification of the ND situation and the way the PAN plans to resolve the situation for the following reasons (MLA12 development and MLA14 development):

- The metaphor suggests that the 'flow' of consumed ND room can be accurately adjusted by opening /closing the tap, but the uncertainties and fluctuations (MLA12) in the actual flow are larger than 'range' of the tap. Additional range could be created by additional source measures to create more ND room but these have never been established (observation MLA14 Development);
- The tapping (release permits) starts with a full glass (no available ND left but majority of the Natura 2000 sites have to CL exceeded) and overflow is unavoidable because it takes time for ND creation measures (source and recovery measures) to take effect. The ND consumption however (permitting of extra emissions) can start rather soon after permitting which will cause overflow immediately;
- In the 'comparing unit' of the control loop, the "zero-reference" point and the process indicators (ecosystem condition sensor-elements) of the ecological status are missing (observation MLA4) and therefore the control loop cannot accurately compare-and-adjust the tap. Controlling the ND consumption flow by means of a "feed forward loop" depends on a well-known relation between the position of the tap and the resulting flow and level in the glass. Because of the uncertainties related to the source and recovery measures, it is unlikely that this feed forward loop will work.

The "adaptation buttons" (besturingsknoppen) and "taking pulse" (vinger aan de pols) are similar simplifications used in the PAN that help to make the PAN understandable but are also misleading considering the very complex ND problem.

The Dutch PAN case study shows irregularities in the monitoring and reporting as well. An example is the remark in the Tauw intermediate report that "the current set-up of the reports are not suitable to track the effectiveness of the source measures" (Bekker & Heijligers, 2018, p. 33). The problem appeared to be a mismatch between emission data reported by the Commissie van Deskundigen Meststoffenwet (CDM) and the actual emission levels. This can be considered a "design-mistake" in the monitoring of source measures.

4.3.2 The Monitoring-Learn-Adapt (MLA)-principle in the Flemish PAN

The Flemish Natura 2000 Plan in 2017 showed the good intentions of the planned monitoring of conservation objectives and how this was integrated in the Flemish PAN (Schauvliege, 2016a, p. 23). But large parts of the monitoring still had to be set-up. The Natura 2000 plan states that "an iterative process of checking, adjustment, planning and execution must be rolled out" (Agentschap voor Natuur en Bos (ANB), 2017a, p. 20) and that the monitoring of ND needed a "revision of the measurement networks to include ND" (Agentschap voor Natuur en Bos (ANB), 2017a, p. 49). The iterative process of checking and adjustment is in line the MLA principle but hardly any examples can be observed in the studied documents about the execution of the monitoring process between 2015 and 2021 (see attachment 2 FMLA3, 6 & 9). No reporting is found on the progress on source measures such as the number of farms that reduced emissions, or stopped/relocated their activities. In general, the case study of the Flemish PAN shows that the monitoring and reporting of the PAN measures is not transparent. An example of the non-transparency in the progress on source measures is the observation that questions in the Flemish Parliament had to be asked to obtain information about the amount of rejected or approved permits within the Flemish PAN framework (Vlaams Parlement, 2020).

Monitoring-Learn-Adapt (MLA)-principle in the Dutch PAN	
ELEMENT	**FINDINGS**
Monitoring	• Good MLA intentions but hardly any examples of monitoring the PAN measures on progress of source measures and recovery measures • Yearly monitoring of ammonia emissions by VMM • Unclear, very brief reporting on ND in the 6 yearly Natura 2000 report in 2018
Learn-Adaptation	• Lack of back-up measures to adapt the PAN • Development of a roadmap (praktische werkwijzer) to support the appropriate assessments and permitting authorities • VLOPS-IFDP model and EMAV model developments • Lack of transparency in the reporting on source measures

Table 4.4: Overview of the findings about the MLA-principle in the Flemish PAN

The ecological monitoring of the PAN recovery measures is aligned with the 6-yearly Natura 2000 reporting cycles on the Conservation goals (Agentschap voor Natuur en Bos (ANB), 2017a, p. 18). As part of the case study, the Natura2000 habitat status report 2012-2018 was screened and this shows a rather superficial reporting and weak link with the PAN (see attachment 2 FMLA8). The report only refers to Nitrogen Deposition as code "X0 threat and pressures from outside the Member State" and as code "A27 Agricultural activities generating air pollution". These threats "X0" and "A27" have, depending on the habitat type, a Medium or High importance/impact. The VLOPS version November 2017 is listed as the source of information (Article 17 Habitat report web tool, 2022). The conservation measures per habitat type are reported in section 8 of the Natura 2000 report. For example, the habitat type 6230 Species-rich Nardus grasslands on siliceous substrates in mountain areas, has 10 main conservation measures (par 8.5) among which *CA12 - Reduce/eliminate air pollution from agricultural activities* and *CA05 - Adapt mowing, grazing and other equivalent agricultural activities*. In a remark below the table, the LIFE and other ongoing projects are listed. The response time of the conservation measures is planned to be medium term (within the next two reporting periods, 2019-2030). This brief analysis of the Natura2000 report shows (1) the high level and often 'coded' way of reporting of the conservation status and (2) that it is difficult to find the contribution of ND in the status on conservation goals in the Natura 2000 report. We argue that the 6 yearly Natura 2000 report is therefore not sufficient to apply the MLA-principle into the Flemish PAN and that more detailed ecological monitoring on the Natura 2000 habitats should have been applied or at least developed.

The Nature and Forest Agency (Agentschap Natuur en Bos (ANB)) is responsible for the reporting about the Flemish PAN recovery measures. The 2018 report exists of 6 pages and in paragraph 3.2 a brief overview is written on the progress of the conservation activities like mowing, planting, exotic species control, etc. (Agentschap voor Natuur en Bos (ANB), 2018). The surface on which these activities take place is used as progress indicator (see attachment 2 FMLAC4). In an interview with H. Van de Wiele (ANB), the reporting of PAN recovery measures is discussed in more detail (personal communication, May 18th, 2022). Since the start of the PAN recovery measures, the reporting was rather informal and on Natura 2000 area level. The reporting mainly focused on the high-level status of recovery projects: which projects are still in preparation, which are in execution and which projects have not started yet. The indicator that is monitored is the surface per habitat type and how it increases per project. As coordinator, H. Van de Wiele emphasized the time-consuming character of recovery projects and long negotiating and planning phase that is needed before starting the project. "The Flemish PAN should be more realistic in that respect" according to H. Van de Wiele (personal communication, May 18th, 2022) .

Ammonia emissions are reported by the Vlaamse Milieu Maatschappij (VMM) on a yearly basis, specifically to measure and adjust the significance framework for permitting (Agentschap voor Natuur en Bos (ANB), 2015, p. 26; Schauvliege, 2016a, p. 27). However, despite the stagnation of ammonia-emissions and even a slight increase in time-period 2017-2020 (Vlaamse Milieumaatschappij, 2022), no clear indications are found in the Flemish case that this adjustment of the significance framework actually took place (see attachment 2 FMLA6, 10 & 14) .

The "Learn-Adapt" part of the MLA principle in the Flemish PAN is clearly demonstrated by study about the Dutch Critical Load values and recovery measures, and adapting them to the Flemish circumstances (De Keersmaeker et al., 2018, p. 21). Other examples are the developments in the Flemish PAN tools (see attachment 2 FMLA-VLOPS1, FMLA14/15 & FUNDC5): (1) improvement of the VLOPS-IFDM model to improve reproducibility and the data input; (2) developments in the EMAV ammonia emission calculation model; (3) adjustments following model validations; and (4) the 'dynamic' practical roadmap (praktische wegwijzer) for permitting authorities (Agentschap voor Natuur en Bos (ANB), 2015). Further, close cooperation took place between experts of the Flemish Environmental Society (Vlaamse Milieumaatschapij (VVM)) and the Dutch National Institute for Public Health and the Environment (RIVM) about ammonia deposition measurements (Vlaamse Milieumaatschappij, 2018, p. 19). These are observations that show learning and adaptations within the Flemish PAN.

Observation FMLA3 in attachment 2 gives an interesting link between the Flemish PAN and the Ecosystem Approach (see also Theoretical Framework, section 2): The Flemish Natura 2000 program states that only a minimum of procedures and obligations will be imposed onto the local level so "this level can concentrate on the realizations in the field" (Agentschap voor Natuur en Bos (ANB), 2017a, p. 18). The interview with D. De Hemptinne (ANB) about the developments and application of the roadmap, confirms the decentralization and this element fits well with the principle 7 and guideline 7.2 of the Ecosystem Approach (personal communication, June 3rd and 9th, 2022).

4.3.3 Partial conclusion about the MLA principle in the Dutch and Flemish PAN

From the case study results we can draw the following conclusions about how the MLA - principle was applied in the Dutch and Flemish PAN (Research question 3):

(3) How is the "Monitor, learn & adapt" (MLA)- principle applied in the Dutch and Flemish PAN?

The findings on the MLA-principle in the Dutch PAN case, show that many good elements of the monitoring, learning and adaptation-elements can be found in the Dutch PAN. Crucial weak points are that (1) the ecological monitoring did not (or rather cannot) reduce the uncertainties regarding the effects of recovery measures, and (2) no back-up source measures were available to adjust the PAN when it became clear that the effects of source measures were disappointing.

Concerning the MLA-principle in the Flemish PAN, we can conclude that many parts of the monitoring system still had to be developed (weakness). The monitoring of the recovery measures is very brief, and the focus is on the regular conservation activities rather than on the recovery projects. The 6 yearly Natura 2000 reporting on conservation goals only gives very brief and high-level information about ND. Hardly any monitoring results are found about the progress on source measures and permitting ND room consuming activities. This reporting lacks transparency as well. The yearly monitoring of the ammonia-emissions is easily available on the VMM website. The 2018-2020 emissions show a slight increase in ammonia emissions, but additional source measures are lacking in the Flemish PAN. This shows that this key element "adaptation" is not applied.

Both case studies show strong learning and adaptation elements during the developments in the PAN tools and ND models.

4.4 Trade-off of economic activities and nature conservation (Research Question 2 and 4)

The Dutch and Flemish PAN case studies show that important trade-offs between economic development and nature conservation took place at various governance levels: at national level by politicians, at provincial level by permitting authorities and at local level by landowners and coordinators of recovery measures. Other actors like environmental NGO's, local politicians, farmers associations played an influencing role in the trade-offs. The findings on the three trade-off levels are discussed below.

Trade-off of economic activities and nature conservation in the Dutch and Flemish PAN	
GOVERNANCE LEVEL	**FINDINGS**
National	• Political decision to 'create ND room' and allow permitting of economic activities (Dutch & Flemish PAN) • Political decision to 'avoid further deterioration of nature' rather then immediately try to improve the conservation of habitats • Political decision that there is no end date for reaching the conservation goals (Flemish PAN) • Focus on the key effects and accept uncertainties and knowledge gaps in quantification. Combine modelling with qualitative approach (Flemish PAN) • Political decision to limit the PAN efforts to Natura 2000 area's and do not include other nature that suffers as well (Dutch and Flemish PAN)
Provincial	• Search Zone approach gives room for local trade-offs and optimize the recovery measures along with landowners and farmers (Flemish PAN) • Trade-off of available ND room mainly done during the Natura 2000 area-analysis and registered in Aerius (Dutch PAN) • "Compensation" measures seem to be applied regularly (Dutch and Flemish PAN) as result of trade-offs during permitting process
Local	• Voluntary cooperation by farmers to apply emission reduction measures. This creates a social dilemma decision (Dutch PAN) • Voluntary decision in the Flemish PAN to relocate or stop farming activities and obtain financial compensation

Table 4.5: Overview of the findings about the trade-offs in the Dutch and Flemish PAN

4.4.1 Trade-offs at national level

The basis for trade-offs between nature conservation and socio-economic activities is prescribed in the Habitat Directive 92/43/EEC of 21 May 1992 (No L 206 / p. 7): "the main aim of this Directive being to promote the maintenance of biodiversity, taking account of economic, social , cultural and regional requirements". In the Dutch PAN we can observe the most fundamental trade-off in the national political process. This process started in 2009 with the decision by the Dutch government to follow the recommendation of the Adviesgroep Huys (KAMERSTUKKEN II 31700-XIV nr. 160, 2009) & Commissie Trojan (KAMERSTUKKEN II 30654-51, 2008) and take an integrated approach to balance economic development and improvement of Natura 2000 conservation status.

Part of this approach was to create ND room for economic development by defining a widely supported set of source measures to decrease ND, as well as recovery measures to increase the resilience of habitats (Bal et al., 2014, p. 6). "Widely supported" was a key element of the approach because it was supposed to unlock the permitting process that was stagnated by the Nature Protection Law 1998. This stagnation hampered the development of new activities for mainly farms near Natura2000 sites (Doekes et al., 2015a, p. 27). We argue that the Nature Protection Law 1998 did exactly what it should do: "protect nature". (See attachment 1 TRO1). The trade-off by the Dutch government to combine nature protection with economic development had a weak basis: ND Room for economic development was not available and therefore it was "created" by applying a set of source and recovery measures with uncertain and marginal effects. The second segment this "ND room"-trade-off in the Dutch PAN was the decision by the Dutch Government to limit the ambition and just create enough ND room to avoid further deterioration of the conservation status. This decision implied that the Natura 2000 conservation goals could only be met on the long term (Ministry of Agriculture Nature and Food Quality & Ministry of Infrastructure and Water Management, 2015, p. par 3.5).

The high-level trade-off between nature and social and economic interests in the Flemish PAN is operationalized by defining source measures only for the most important ND polluters: the red and orange farms. The red-orange-green classification of relevant activities, mostly farms, was based on an impact assessment in 2014/2015 by a working group "spatial impact analysis" with representatives of INBO, VITO, VMM, VLM, ILVO en ADLO (Cools et al., 2015), see also attachment 2 FMLA-VLOPS2. The large majority of farms in the green category could proceed their activities undisturbed. The Flemish Government did not plan an end date for reaching the conservation goals (Schauvliege, 2016a, p. 2), which is another high-level political trade-off about the limited efforts that are planned to be taken to reach the conservation goals. Other principles that are considered during the establishment of Flemish are the "creation a level playing field", avoid "gold plating" and assure "participation at local level" in the balancing act (see attachment 2 FTRO 1, 2 &3). These principles are not further explained in the documents that are studied and an interview with D. De Hemptinne and H. Van de Wiele showed that these principles are rather unknown at operational level (personal communication, June 3rd and 9th, 2022 and May 18th 2022).

An interesting high-level trade-off in the Flemish PAN is related to the right level of detail needed for the plan-MER. As stated in the notification letter Environmental Effect Analysis PAN, the level of detail in the plan-MER should fit with the "strategic stadium of decision making" (KENTER, 2018, p. 36) and it should be acknowledged that there are limits to quantifying the ND-problem and the PAN effects (see attachment 2 FTRO4). This statement puts uncertainties and knowledge gaps in the Environmental Effect Analysis PAN in perspective: the key-sources and effects in ND are known well enough to make strategic decisions and there is no need to narrow down the sources and effects further. This approach taken in the Flemish PAN to focus on "key-effects", helps to balance between quantitively (modelling and calculations) and qualitative data. A statement by nitrogen expert Erisman in the experts debate in the Dutch Government supports this quantitative/qualitative approach. Erisman suggests that enough studies and measurement-data is available to support the nitrogen policy. Erisman gives the example of the use of a distance table for permitting decisions in the past. This was inaccurate but used in the past for permitting and worked well. "The sophisticated models of today", Erisman argues, "have detailed but inaccurate calculations but the zero-level is the same" (Erisman, 2022). We can expect that this rationale about the level of data-accuracy needed to support policies can be easily applied to the PA for EUS in general.

The lingering Environmental Effects Review of the Flemish PAN that ran between 16 aug 2018 and 16 Oct 2018 never became published officially (see attachment 2 FTROND5). Therefore, it was a regular topic for debate in the Flemish Parliament between 2015 and 2021. The considerations, questions and responses in the Parliament (see attachment 2 FTROND6) illustrates the balancing act between the legal robustness and the legal uncertainties "that is a characteristic of the instrument "(Vlaams Parlement, 2015, p. 17). Nevertheless, on 25 febr 2021 the Ravels ruling RvVB-2021-0697 ended the preliminary PAN measures and locked the permitting system despite years of "balancing"(Raad voor Vergunningenbetwistingen, 2021).

The Environmental NGO's Natuurpunt and BBL mention an important trade-off principle in their PAN Guidelines (see attachement 2 FTROND1): The Flemish PAN should not only deal with conservation goals within Natura 2000 area but also with nature conservation outside of Natura2000 area. The nitrogen problem outside Natura 2000 habitats is well acknowledged but not further considered in this thesis.

4.4.2 Trade-offs by permitting authorities

At the level of provincial governance, the Dutch PAN offers the opportunity for competent authorities to set specific rules for the allocation of ND room. An example of such specific rules are requirements regarding environmental performance that can be added as condition for permitting new activities (see attachment TOND3). This raises the question if and how trade-offs are made in this regard. What kind of environmental performance is demanded? And how this is enforced? The interviews with D. De Hemptinne and M. van Ligten (personal communication, June 3rd and 9th, 2022 and May 11th 2022) give indications that "compensation-measures" are applied regularly as part of the permitting requirements, that could be considered "compensation" for damages or lost nature. As Squintani & Zijlmans explain in their paper about mitigation and compensation under the Habitat Directive, the applicationof compensation measures is grey and questionable practice and only allowed in cases of "imperative reasons of overriding public interest" (Squintani & Zijlmans, 2019, p. 5).

In the Dutch PAN, the trade-off by permitting authorities is rather straight forward compared to the Flemish situation. In The Netherlands, the permit decisions are supported by the AERIUS monitoring tool that calculates if still enough ND room is available for the requested activity in the particular area or not. The available ND room was determined per area in the Natura 2000 area analysis but little information can be found about the trade-off in these area analysis between allowing new activities on the one hand and protecting habitats on the other hand. The PAN assessment report by PBL sheds some light: PBL suggest that the PAN gained support among local Natura 2000 stakeholders because the PAN guaranteed funding for recovery projects and more clarity about governmental responsibilities. (See attachment 1 UGA5, 6 & 7). The governmental clarity and funding would be perceived by conservationists as interesting opportunity to finally execute recovery measures that were pending for many years (Folkert et al., 2014, p. 7). This PBL statement gives the impression that the PAN helped to persuade conservationists to agree with the new ND room in the orchestrated area analysis that legitimized the new ND room (see also textbox in section 4.2.3).

The AERIUS monitoring tool reduced the permitting to bookkeeping of requested and available ND room per habitat. This methodology 'simplifies' the local circumstances and this is a weak point. Nature conservation assessments need more sophistication as clarified in an interview with M. van Ligten (personal communication, May 11th 2022). The perspective that Van Ligten gave was that "*the 2nd and 3rd order effects of decisions and human activities on ecosystems are often unknown. Nature is not 'man-made' and we should just give nature space and opportunity to let ecosystems and habitats organize* *themselves*". This ecological perspective conflicts with the Dutch PAN that considers Natura 2000 as a product that can be consumed, produced, or put on a HOLD.) The nationally orchestrated determination of the available ND room per area (see textbox on 4.2.3) is contradicting with the ecosystem approach principle 7 that recommends that the monitoring and assessment should be undertaken at the local level (Secretariat of the Convention on Biological Diversity, 2004, p. 7).

A major difference between the Dutch and Flemish PAN is that the Appropriate Assessment in the Dutch PAN is applied at program level and in the Flemish PAN each permit request must be appropriately assessed individually. The interviews with D. De Hemptinne showed that the appropriate assessment integrates multiple possible significant effects on habitats, not just the effects of ND. Guidelines like the Roadmap Eutrophication through air (Agentschap voor Natuur en Bos (ANB), 2015, p. 46) are being developed to support these assessments (personal communication, June 3rd and 9th, 2022). Operational Objective 3.3 and action 26 of the Natura 2000 program (Agentschap voor Natuur en Bos (ANB), 2017a) describes the setup of multiple PA's for environmental pressures and creates a strong link between the PA's and the conservation goals (see attachment 2 FTFR4). This integrated approach that oversees multiple pressures and takes the local circumstances into account during the appropriate assessment, is a strong point in the Flemish PAN.

In the permitting trade-offs in the Flemish PAN, the Search Zone Approach[16] plays an important role. The Search Zone model creates a specific trade-off type in the Flemish PAN: The Search Zone method operationalizes the balancing of conservation goals and socio-economic interests quite literally, because it "corrects conservation goals for socio-economic impact" (Vlaams Parlement, 2015, p. 5). This interpretation by the Flemisch govenment however, holds a contradiction with the definition of "Search Zone" in the Nature Decree (see attachment 2 FTRO-SA1) in which this "correction for socio-economic impact" is not mentioned.

During the extensive and complex Search Zone-process, the local conservation goals of the Natura 2000 area are assigned in the most optimal way while taking into account the human activity and developments. The Search Zone method is discussed in the interviews with D. De Hemptinne and H. Van De Wiele and they explained that this is a slow process which links the Appropriate Assessment of permitting requests with the planning of recovery measures (personal communication, May 18th, June 3rd and 9th, 2022).

From observations FTRO-SA7 & FTRO-SA8 in attachment 2 we can learn that more than 60% of the Flemish Natura 2000 areas (104.298 ha in total) was Search Zone in 2015. During the placement of protected habitats within the Search Zone so far, about 20% is left over as free space for human activities.

Further, it is interesting to add that the complex trade-off between nature and socio-economic interests using the Search Zone method is appreciated and shared as good example by the Directorate General Environment of the European Commission (Vlaams Parlement, 2015, p. 13). See also attachment 2 FTRO-SA5.

4.4.3 Trade-offs at local level

At local level, two important trade-offs are described by the PBL assessment report (see attachment 1 US2, US3, TO2, DUL6): (1) Landowners can contribute to hydraulic or other recovery measures on voluntary basis and therefore must make the trade-off if, and under what condition, they want to cooperate, and (2) farmers must trade-off the value of their voluntary investments in emission reduction. For both (1) and (2) the contributors and/or investors are not necessarily the parties that benefit from the created ND room. The social survival dilemma ((Steg & Vlek, 2010, p. 120) that is created by this voluntary contribution could hamper the expected results of both the recovery measures and voluntary source measures. See also discussion section 5.

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[16] The Search Zone method operationalizes the balancing of conservation goals and socio-economic interests quite literally by interpretation of the Flemish Parliament (Vlaams Parlement, 2015, p. 5) "'zoekzone' houdt de afbakening in van dat deel van de beschermingszone waarin doelen kunnen worden gerealiseerd. Dat gebeurt binnen het hoogste natuurlijk potentieel en **wordt gecorrigeerd volgens de sociaal-economische impact**". However, the Nature Decree gives in art 2 a definition in which "**correction according social-economical impact**" is not mentioned! This is remarkable and shows how the Flemish government makes the trade-off between nature protection and social-economic interests. See attachment 2 FTRO-SA 1, 3 & 9 for the basic steps of this process and for a brief explanation of the method.

In the Flemish PAN, the decision to stop or relocate 'red' farm activities was voluntary as well and for the individual farmers to decide. The trade-off that can be recognized is if the financial compensation for stopping or relocation was sufficient for farmer or not. The case study showed that only 10 of the targeted 54 red farms used this opportunity (see also section 4.2.1).

The interview with H. Van De Wiele about trade-offs during planning and execution of PAN recovery measures, shows that the borders of Natura 2000 Areas are not strictly followed in many cases. Instead, a local cross-border approach is taken during the development of recovery measures. This increased opportunities and stimulates the participation of stakeholders. If a farmer or landowners is capable and willing to cooperate voluntary, also outside the protected area, than this is incorporated into the recovery plans (personal communication, May 18th, 2022). This cross-border approach can be considered a strong point.

4.4.4 Partial conclusion about the Trade-offs in the Dutch and Flemish PAN

From the case study results about trade-offs in the Dutch and Flemish PAN we can formulate answers to research question 2 and 4:

(2) How is the Environmental Utilization Space for Nitrogen Deposition (EUS-ND) determined and who is involved in this determination?

Both the Dutch and Flemish PAN create ND room by using a part of the prognosed downward ND trend, added with source measures that aim to reduce ammonia emissions. The Dutch PAN is more explicit in determining and quantifying this created ND room than the Flemish PAN and "legitimizes" the newly created ND room with Natura 2000 area analysis reports. In the Flemish PAN, the Natura 2000 area analysis are conducted with the objective to find the best possible recovery measures for the different habitat-types. An impact assessment is conducted to establish a list of ND polluters using models and calculations. This list is split into "Red", "Orange" and "Green" activities. The Red activities were expected to stop or relocate because the permits would not be extended, the orange activities could extend activities only when emission reduction measures would be taken. The Green activities would not be affected. The stopping of red activities and emission reduction by orange activities, in addition to the downward ND trend, would create the new ND room for the Flemish PAN.

The amount of ND room and the reliance on the downward trend of ND, are political decisions. This is also the case for the decision to take just enough measures to avoid further deterioration of the habitats rather than taking measures to improve the habitat conservation status This shows the low ambition among Dutch and Flemish politicians and the power of the farmers coalition in the PAN cases.

(4) What trade-offs in the permitting process determine the balancing of socio-economic development and nature conservation interests and which actors influence these trade-offs?

In the Dutch PAN the permitting process and authorities are supported by the AERIUS monitoring tool. This tool helps to monitor the available ND room per Natura 2000 area and is used to assess if there is still ND room available to permit a new activity. The trade-off is reduced to mere bookkeeping with little room for anticipation on local circumstances and ecological interests.

In the Flemish PAN, the trade-off during the permitting process is more sophisticated because the Appropriate Assessment is used for each permit request. During this Appropriate Assessment, local knowledge and circumstances can be taken into account, alignment with recovery measures can take place, and multiple environmental pressures can be integrated in the same assessment. In parallel to this procedure, Flanders uses the Search Area methodology to place conservation objectives optimally in a Search Zone. This gives local authorities another instrument to trade-off conservation goals with socio-economic interests.

4.5 Summary of the findings (Research Question 5)

Research question 5 asks:

(5) *"which findings from the Dutch and Flemish PAN cases can be translated into more general design-principles for a Programmatic Approach?"*

The findings are listed in the table below per research aspect. The labels ✓ and ☒ show if the finding can be considered a strength or a weakness with respect to the success of the PAN. In this section we make the link between the findings per research aspect and the general design principles for a PAN.

Uncertainties in the Dutch and Flemish PAN:
The various sets of uncertainties that are distinguished in the case studies all have their specific strengths and weaknesses. The uncertainties in the ND models AERIUS and VLOPS-IFDM and calculations are significant (30-70%) and obtain a lot of attention in the studied documents. However, this level of uncertainty is, compared to the ND critical load exceedance of more than 50%-100% in many cases, relatively small. Therefore, the model uncertainties should not be used as an excuse for not acting and reduce emissions *(Weakness).*
The learning element during expert reviews, research, and adjustments of the AERIUS and VLOPS-IFDM can be clearly observed in the case studies (*strength*).

Strengths and weakness in the Dutch and Flemish PAN Based on 512 quotations in 39 research documents (2850 pages) using 37 codes		
Research aspect	**PAN**	**Strength ✓ /Weakness ☒**
Uncertainties	Dutch/Flemish	✓ Available models and understanding of their uncertainties
	Flemish	☒ Lack of transparency about uncertainties
	Dutch/Flemish	☒ Optimistic rather than realistic prognosis (Livestock)
	Dutch/Flemish	☒ Dependency on willingness and voluntary cooperation of farmers and other landowner
	Dutch/Flemish	☒ Likely lower effectiveness of source measures and recovery measures not acknowledged
	Dutch	☒ Considerable uncertainties in the effect of recovery measures, but nevertheless new ND room was legitimized and made available (Dutch PAN)
MLA principle	Dutch/Flemish	✓Monitoring and adjustment plan described and part of the PAN
	Flemish	☒ Many MLA elements described but still to be developed
	Dutch/Flemish	✓ Expert reviews, research, and adaptations to make models and calculations more accurate
	Dutch/Flemish	☒ No back-up source measures to adapt the PAN in case of disappointing results
	Dutch	☒ Oversimplification of the MLA principle with hand-on-the-tap and other metaphors, creating false idea of being-in-control
	Dutch/Flemish	☒ Ecological monitoring not sufficient for proper application of the MLA-principle
Trade-offs	Dutch	✓/ ☒ The “Monitoring” function in the AERIUS model gives clear direction (strength) but also reduces the permitting process to mere bookkeeping (weakness)
	Flemish	✓Roadmap as clear guideline for appropriate assessment and permitting decisions, overseeing multiple integrated pressures
	Flemish	✓Search Zone method is time consuming and intensive process but helps to balance conservation goals with economic development

Table 4.6: Overview of the strengths and weaknesses in the Dutch and Flemish PAN

The uncertainties related to the effects of source measures and recovery measures are more explicitly described in the Dutch PAN but also the Flemish PAN shows attention for this set of uncertainties. Most source measures depended on voluntary cooperation of landowners and farmers (*weakness)*.

The uncertainties in the ND levels following the ND prognosis and downward trend are not clearly described in the Flemish PAN but the observations show that downward trend depends on expected cease of farming activities (3-4% / year) and the transformation to low-emission stables. In the Dutch PAN, the prognosis lacked important elements like the "stagnation effect" and the "dormant room effect" and underestimated the possible growth of livestock. Both the Dutch and Flemish PAN were based upon an optimistic prognosis. Besides, no back-up plan was in place for adaptation of the plan for the likely disappointing results *(weakness).*

Another important set of uncertainties consist of the complexity in execution of recovery measures and their effects. Proper and successful execution of the extensive set of recovery measures is an important pre-condition for the "standstill" of conservation status in Natura 2000 areas in the Dutch and Flemish PAN. The success of recovery measures is far from certain, and it can take a long time before the measures show the desired effect. Besides, the ecological effects are difficult to monitor so the monitor-learn-adapt principle is difficult to apply in the quantitative way that the Dutch and Flemish PAN pretend to do *(weakness*). The Dutch Natura 2000 area analysis formally legitimize the available ND room despite the exceedance of the critical load levels in many areas, and uncertainties in the effects of the recovery measures (*weakness*).

Both the Flemish and Dutch PAN showed to be successful in unlocking the permitting process for a period of 4-5 years. The ND room was consumed swiftly. The optimism regarding the effects of recovery measures and source measures, in combination with opening the tap for new ND consumption, created an imbalance in ND room: more ND room was consumed than created. It can be expected that this led to further worsening of the conservation status of nitrogen sensitive Natura 2000 areas (*weakness*) and the failure of the PAN as instrument to govern ND.

The legal uncertainties were reduced as much as possible in the Dutch and Flemish PAN which can be considered a *strength* from socio-economic development perspective. The poor legitimization of additional ND room, that was under debate from the start and led to the court rulings that ended Dutch and Flemish PAN, clearly is a *weakness* in the Dutch and Flemish PAN.

Monitor-Learn-Adaptation (MLA)-principle in the Dutch and Flemish PAN:

The Dutch and Flemish case studies show many elements of the MLA-principle: monitoring systems, reporting cycles, and measurement networks (*strength*). In the Flemish PAN, many of these elements were still in development between 2015 and 2021 and lacked transparency (*weakness*). The applied models and calculation programs showed improvements and developments, for example as results of expert reviews and the validation of the models with emission and ND measurements (*strength*).

As also mentioned before, a weak point in both the Dutch and Flemish PAN is that adjustments in the PAN were not possible because the PAN did not foresee in back-up measures. If the ND would not decrease, more stringent source measures should have been applied to drive the emissions down further, but these extra measures were never agreed. Therefore, adjustment of the PAN was not possible, and the MLA-principle could not be applied. *(weakness).*

A *weakness* in both the Dutch and Flemish PAN is the monitoring of ecological effects and the conservation status. Ecological monitoring is complex and proper indicators still had to be developed. Besides, there of is a time-lag between the change in emissions and the time that the ecological effects can be observed. The complexity of ecological monitoring contrasts strongly with the metaphors "hand-on-the tap", "pulse-check", and "control buttons" that are used to describe the MLA principle. These metaphors give a false idea of being-in-control of the complex balancing act for which the PAN was set-up. Instead of proper balancing of nature conservation with economic development, the execution of the Dutch and Flemish PAN was rather, to use another metaphor, 'driving blind with a locked steering wheel' *(weakness)*

Trade-offs in the Dutch and Flemish PAN:

As third research aspect, the trade-offs between nature conservation and socio-economic development in the Flemish and Dutch PAN were studied. The trade-offs by permitting authorities in the Dutch PAN were strongly directed by the AERIUS monitoring and calculation tool. The 'bookkeeping' function of the AERIUS tool reduced the trade-off to a mere comparison of available versus requested ND room. This method is transparent, traceable, and controllable *(strength*). From ecological point of view however, this piece of arithmetic is an oversimplified way to assess permit requests. It suggests make-ability of habitats and nature and leaves little room to agree upon case-by-case ecological measures and local circumstances *(weakness*). In Flanders, the appropriate assessment, that must be conducted for each individual permit request, consists of a more integrated approach to assess permit requests while overseeing multiple pressures. Clear guidelines (called "roadmaps") are in place for the permitting authorities, and this gives more control on the way measures are incorporated. The roadmap also gives room for the competent permitting authorities in Flanders to involve Natura 2000 coordinators and anticipate on the local circumstances *(strength*). The Search Zone methodology in Flanders is another element that helps to balance habitat conservation with socio-economic developments in Natura 2000 areas (*strength*). The Search Zone methodology is used in the Flemish Natura 2000 program to place habitats and species optimally within the Natura 2000 areas, incorporating local knowledge and circumstances.

The Dutch and Flemish PAN heavily depend on the willingness of farmers and landowners to cooperate with source measures and recovery measures. The individual trade-offs and decisions by landowners and farmers create a social dilemma: Am I willing to invest for the benefit of others and for the common good? The dependency on this willingness and the social dilemma is known to be a *weakness* in environmental governance (Hardin, 1968; Steg & Vlek, 2010, p. 120).

5. Conclusions, discussion & recommendations (Main research question)

In this concluding section we circle back to the main question of this research, present the main conclusions, and reflect on the study and study results in the discussion part. A few recommendations for further research are incorporated in the discussion section. The main research question guiding this study is

"What strengths and weaknesses in the Dutch and Flemish PAN determine their success/failure regarding its effectiveness as Programmatic Approach to reduce ND in Natura 2000 sites and how do these empirical findings relate to the Programmatic Approach as environmental governance instrument?"

The overall conclusion is that the Dutch and Flemish PAN were not successful. The ND levels did not decrease but rather increased. The imbalance in creation and consumption of ND room remained or even worsened. The downward trend in ND levels and the source measure to create additional ND room had many uncertainties that all tended towards a too optimistic trend prognosis. Little doubt however, existed about the urge to resume ND Consumption by permitted new activities, and that the allegedly "created" ND would be consumed in a short period of time. No adjustments were possible because the Dutch and Flemish PAN lacked back-up measures. Hence, the ND Environmental Utilization Space was brought even further out of balance. It must be noted that the poor political ambition was contributing to the failure of the Dutch and Flemish PAN. The order of magnitude of 1% ND /year reduction while most habitats have and ND critical load exceedance of 50-100% is simply not enough. If the Dutch and Flemish PAN would have been more ambitious, for example by measures that would have created ND room directly and be measurable at the start of the PAN, these instruments could have led to much better results. The BIJ12 report "Landelijke monitoringsrapportage Natura 2000 en Stikstof 2020" puts the PAN ambition in perspective: with the PAN in the first stage the main goal is to avoid further deterioration of the nitrogen sensitive habitats. However, the conservations status in the Netherlands is already below average in the EU (BIJ12, 2021, pp. 11, 12).

With this research we want to obtain insights about how the findings of the Dutch and Flemish PAN cases relate in general to the PA as environmental governance instrument (2nd part of the research question). Before we discuss these insights, we formulate the conclusions from the case studies. Figure 5.1 illustrates the findings in the out-of-balance EUS ND model.

(1) The prognosis of the autonomic downward trend of ND was too optimistic
The expected continuation of the downward trend in ND for the coming decade, based on the trend in the previous decade, was too optimistic. In particular, the growth of livestock was not foreseen. In both the Dutch and the Flemish PAN, the assumption was that current policies and developments in cleaner technology for transportation, industry, and stables, would ensure further decrease in ND levels. The rationale in the PAN was that this downward trend could justify new economic activity without increasing the ND levels. Furthermore, the prognosis proofed not only to be too optimistic, but also this rationale was wrong: if ND levels would indeed decrease because of cleaner technologies, this does not necessarily imply that nitrogen problems in individual Natura 2000 areas decrease. An overall decrease in NOx emission levels because of cleaner transportation and combustion processes, will not compensate the extra ND on a Natura 2000 area because of the expansion of a nearby farm.

(2) The limited and voluntary measures kept the ND-EUS out of balance from the beginning
The uncertainties in the ND room creation existed of (1) developments in livestock size, (2) the effectiveness of source measures, and (3) effectiveness of recovery measures. The voluntary character and lack of enforceability of source and recovery measures reduced their effectiveness. Besides, the prognosis about the autonomous downward trend in ND was rather optimistic and missed essential elements like the growth of livestock. Therefore, the planned creation of ND room was highly unlikely. The lowest uncertainties can be found at the ND room consumption side of the balance: Both the Dutch and Flemish PAN paved the way for unlocking the permitting system and stop the stagnation in ND room consumption. We can conclude that the uncertain creation on the one hand, and the rather certain consumption of ND room, created an unbalance from the beginning of the Dutch and Flemish PAN. Since a Programmatic Approach should be designed to establish and keep this balance, we can conclude that the Dutch and Flemish PAN could never be effective.

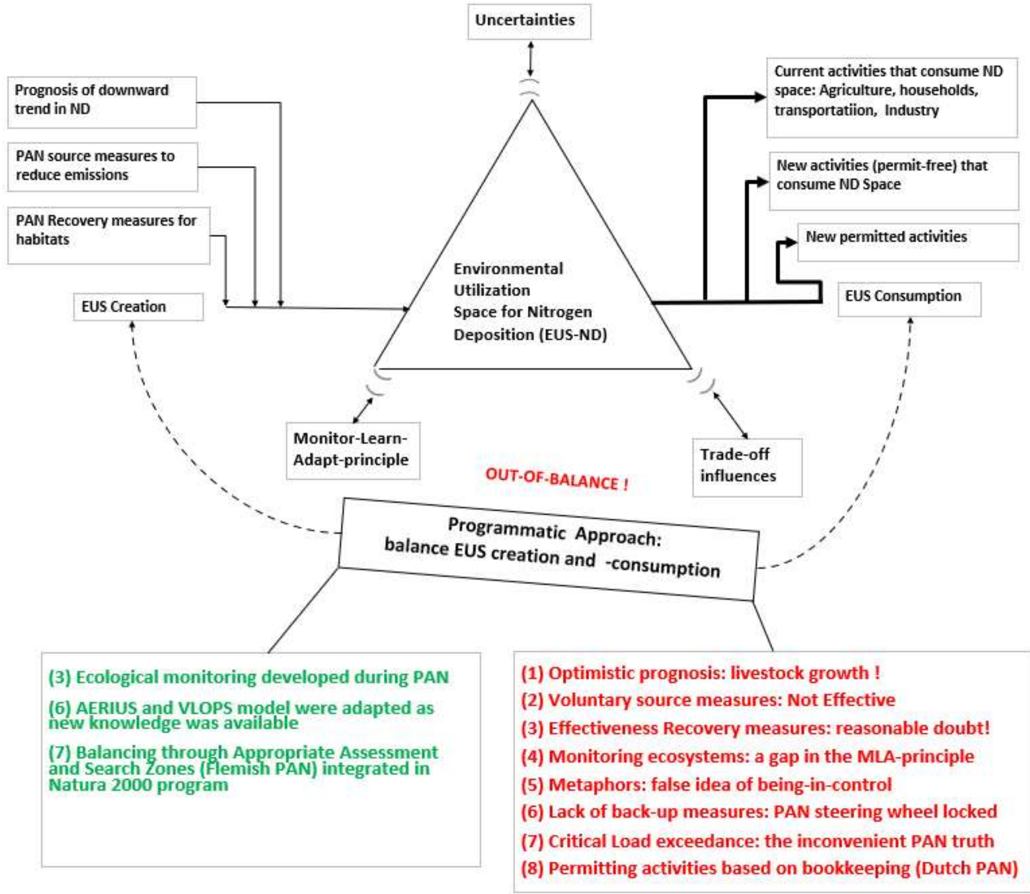

Figure 5.1 The EUS ND model with research aspects Uncertainties, MLA principle and Trade-off influences. Uncertainties are part of any PA and must be acknowledged and reduced by adequate monitoring, learning from the data, and adaptation of the PA. In the permitting of activities under the PA, trade-offs are made by authorities. The PA should give guidance to the authorities to make the right trade-offs and keep the balance between socio-economic interests and nature conservation. See further section 2 Theoretical Framework EUS. The findings from the case studies are added in green (strong points) and red (weak points). The numbers refer to the conclusions. The thick consumption-lines and sloping PA rectangular illustrate the out-of-balance EUS-ND in the Dutch and Flemish PAN cases.

(3) PAN Recovery measures: reasonable doubt about their effects and a violation of the precautionary principle.

The PAN recovery measures intended to increase the resilience of damaged habitats so they can better withstand further pressure by ND in the coming years. Especially the Dutch PAN links the recovery measures directly to extra ND room for new activities in one and the same program. Therefore, we consider the PAN recovery measures a compensation for the unbalance in ND creation and consumption.

Some recovery projects can indeed initiate the development of new "man-made" habitats or improve their resilience but there is reasonable doubt about the success of their results. The success of recovery measures is a pre-condition in the Dutch and Flemish PAN for new socio-economic activities. Because of the reasonable doubt about the success of the recovery measures, the Dutch and Flemish PAN are a violation of the precautionary principle.

(4) The ecosystem monitoring is a gap in the monitor-and-adjust-loop

The monitoring of ecological effects is an essential, but complex part of the Dutch and Flemish PAN. At the start of the Dutch and Flemish PAN, the system to assess and monitor the ecological effects still had to be developed. And once indicators were available it still took years to obtain reliable results. The links between NOx and NH3 emissions, the deposition levels of reactive nitrogen, and the ultimate effect on ecosystems is well known but not suitable to monitor-and-adjust as intended in the Dutch PAN with a bookkeeping approach. If ecological monitoring results are finally available after a long time, then it causes discussion about the link between the emissions and the observed ecological effects because other pressures like climate change, land use, play a role as well. Therefore, the ecological monitoring is a gap in the monitor-and adjust mechanism of the Dutch PAN and, to a lesser extent, in Flemish PAN, despite many good developments and efforts to establish the ecological monitoring system.

(5) Metaphors in the Dutch PAN give the false idea of being in control
A remarkable phenomenon in the Dutch PAN is the use of metaphors that oversimplify the monitor-and-adjust process. ND is a complex problem and metaphors can indeed help public, politicians and non-experts better understand the way the PAN is intended to work. At least in theory. In practice however, the metaphors "hand-on-the tap", "pulse-check" of habitats, and "control-buttons" that can be used to adjust the program, create a false idea of being in control of the ND problem.

(6) Lack of back-up PAN source measures: steering with a locked steering wheel
The main purpose of the Dutch and Flemish PAN was to permit a well-defined and quantified amount of socio-activity without further deterioration of the nitrogen sensitive Natura 2000 habitats. The ND levels should come down slowly at a pace of approx. 1% per year by reducing the amount of ammonia emission. Proper steering of the program towards this goal needs room to adjust for possible, if not likely, disappointing results. This adjustment room must be made available by agreed back-up measures that can be applied as needed to keep on track with lowering the emission levels. The Flemish PAN is not clear about the back-up measures but expects that the sectors will take their responsibility. In the Dutch PAN, the need for back-up measures was acknowledged but concrete measures were never agreed. Therefore, proper adjustments were not possible, and we conclude the Dutch and Flemish PAN unlocked the permitting system but locked the steering wheel that was needed to drive ND levels down.

(7) Much attention for model uncertainties but ignorance of the Critical Load exceedance levels
Industry, farmers, politicians, and scientists all understand that the high levels of ND causes havoc in our protected habitats. However, the uncertainty levels of up to 70% in the local ND modelling and calculation of individual emitters creates a lot of discussion. Too much discussion considering the huge exceedance of critical load levels by 50%-100% on most of the Natura 2000 habitats. With these exceedance levels, the planned decrease of ND levels of a mere 1% per year between 2015 and 2030 can only be perceived as an ignorance of the critical load (or the EUS-ND boundary) in the ND problem.

(8) ND bookkeeping in the Dutch Pan versus permitting trade offs using roadmaps and Search Zones
The PAN in The Netherlands and in Flanders unlocked the permitting system for new activities that became nearly impossible under the Nature Protection Law 1998 and the nature Decree respectively. One of the most remarkable differences between the Dutch and the Flemish PAN is the permitting procedure. Since the Dutch PAN was Appropriately Assessed as total plan, the individual permit request did not need any further appropriate assessment. Instead, the AERIUS ND calculation in the permit request and the available ND room in the applicable area was decisive for the approval or dis-approval of the permit request. The first come first serve principle was applied and permits were approved swiftly in the first years. The trade-off in the Dutch PAN was reduced to the bookkeeping of ND Room. This is transparent and controllable and gives a strong guidance for competent authorities. The Dutch PAN case however also shows the downside of this method: the "bookkeeping" leaves little room for integration of ecological recommendations and anticipation on local circumstances.

The Flemish PAN gives the competent authorities much more power in this respect. A list of green, orange and red businesses has been set-up based on the level of ND they create on the Natura 2000 habitats. The red businesses, mostly farms, were expected to relocate or stop their activities before 2030. For the other businesses, the list determines if a permit for continuation or expanding the activity is needed or not. Each permit is appropriately assessed using clear guidelines or "roadmaps". Nature 2000 habitats are complemented with "Search Zones" in which the most stringent critical load level of present habitats is applicable, but in which still is to be decided which part will be habitat and which parts will be free area. Both the appropriate assessment and the search zones give competent authorities strong instruments to balance nature conservation and socio-economic activities at a local level during the permitting procedure.
The Dutch bookkeeping method is more transparent and legally robust and traceable. The Flemish method leaves a degree of legal uncertainty because of the appropriate assessment procedure and the search zones that are considered habitats until it is decided that parts are not. We argue that balancing socio-economic activities within or close to protected habitats is much more than bookkeeping of ND room and needs case by case assessments and trade-offs by competent authorities that take local knowledge and circumstances into account. Even if this reduces legal certainty for businesses.

The PA as Environmental Governance instrument

Building on these conclusions, we revisit the second part of the main question: *How do these empirical findings relate to the Programmatic Approach as environmental governance instrument?*

The basic idea of balancing EUS with economic development using a programmatic approach is widely supported. It creates a platform to balance ecological and socio-economic interests by integrating both into one integrated program that is established, monitored, and adapted as needed. From the Dutch and Flemish PAN cases we obtained a few insights on how this balancing act works in practice.

Balancing act and the Critical load exceedance

First, the balancing act cannot be successful if the available EUS and the EUS threatening pressure are too far out of balance. In that case, a major reduction in the pressure should first be achieved before the steering process can start. High uncertainties should not be an excuse to postpone the strong, maybe difficult responses that reduces the pressure to a level that matches the critical load within a reasonable time. Figure 5.2 shows such a strong response as a "process change". If the political willingness for such strong Process Change- measures lacks, then the integrated program with measures, monitoring and adjustment will, in the best case, lead to a situation that is only a little less harmful.

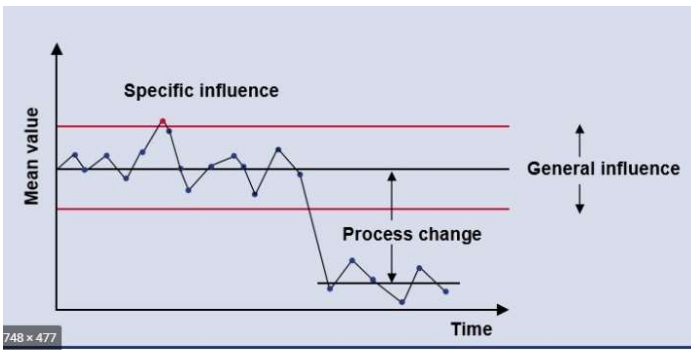

Figure 5.2: Controlling a process around a mean value and the process change to improve the process. Source: (IT-Telesis, 2022)

Voluntary (back-up) measures and the social dilemma

Secondly, to properly steer an environmental pressure downwards, within a bandwidth of uncertainties, steering margin must be part of the program. Regulations can be relaxed if the effects are better than expected, but more stringent back-up measures must be taken if the results lack behind. In this context, the Dutch and Flemish PAN illustrate that a high dependency on willingness to cooperate is a weak basis for a Programmatic Approach. Individual businesses act in the interest of the continuation and survival of that business. Risks for other businesses or habitats are diminished in favor of the own business profits. Furthermore, such a voluntary approach creates a social dilemma: Will I as individual business make investments while the benefit will not be directly for me but to create space for other to expand? Voluntary decisions like emission reduction investments or changing activities to reduce a kind of environmental pressure will call for individuals solidarity with peer businesses. This social dilemma is a weak basis for a PA. Clear, obligatory, and enforced measures can create the same level playing field for all business in the same sector and we argue that this is a better basis for business planning and to drive innovation and transitions.

Bookkeeping and ecological monitoring: lead- and lag-indicators

The third insight that the Dutch and Flemish PAN cases gave is the contrast between the need of tracking progress in the program on the one hand and the complexity of ecological monitoring on the other hand. It takes time to develop ecological indicators to assess if the program has had the desired effects. This can take many years while politicians, stakeholders and the public need immediate feedback on the progress and performance of the program. It this respect it is recommended to clearly distinguish between "lag" indicators and "lead" indicators. Lag-indicators observe the results of past performance. Ecological indicators are generally lag-indicators. The bookkeeping of ND room or levels of ammonia emission can be considered lead indicators and predict probable results of current performance. Both types of indicators should be part of the MLA system.

Integrated Assessment with use of local knowledge and circumstances

The Flemish PAN applied the appropriate assessment for each permit assessment while in the Dutch PAN the monitoring of available and spend ND room was the main tool for permitting new activity. The Dutch approach is transparent, efficient and reduces the administrative burden of individual appropriate assessments as per habitat directive art 6.3. In the Flemish PAN, not only ND but also other pressures are considered during the same permit request assessment. Besides, local Natura 2000 circumstances, knowledge and conservation objectives can incorporated which makes the balancing between socio-economic activities and conservation goals more effective. Despite the time consuming and intensive permitting process, the Flemish approach is expected to be more beneficial for the effectiveness of a Programmatic Approach.

Discussion and recommendations

In this thesis we studied two very specific PA cases: the Dutch and Flemish PAN cases. Both cases dealt with reactive nitrogen deposition as environmental pressure. The studied time-period was limited to 2015-2019 for the Dutch PAN and 2015-2021 for the Flemish PAN. Further, only the three main research aspects “uncertainties”, Monitor-learn-adapt-principle”, and “trade-off influences” were given attention. Other research aspects or another perspective, for example a more juridical or ecological perspective could have resulted in other findings. The study of other PA-cases like the Air Quality Directive or the Water Framework Directive could also have yielded other, probably more positive, findings. To our opinion however, this study of 39 reports and 5 expert interviews about the complex ND problem and the response using a PAN, gives insight in the elements that must have proper attention when applying a PA to balance socio-economic interests with conservation objectives.

A few remarks must be made when the results are compared with other literature on this topic. The conclusion that the dependency on voluntary cooperation is a weak point in the Dutch and Flemish PAN, is in line with the paper by Kegge & Drahman in the Journal for European Environmental & Planning Law, that describe voluntary measures as “unsuitable by their nature because the effects of those measures will usually be uncertain” (Kegge & Drahmann, 2020, p. 82). Kegge & Drahman also suggest to make permitted activities reversible in case the objectives cannot be reached by merely adjusting the plan to be in compliance with the precautionary principle (Kegge & Drahmann, 2020, p. 83). These statements support our conclusions. The voluntary character of the PAN source and -recovery measures appear to make the creation of ND room most uncertain. The reversibility of permits that Kegge & Drahman suggest, could, at least in theory, help to adjust the balance of created and consumed EUS. However, even if this is carefully agreed among the authorities and businesses, this practice can be seen as rather unfair. A second remark we like to add is with regards to the critical load for an EUS. An interesting perspective is given by Bastmeijers in his work on the Ecosystem Approach, humans and lessons from the Natura 2000 regime. Bastmeijers opinion is that the Ecosystem Approach can work well as long as here is still Environmental Utilization Space available that can be allocated for socio-economic activities. If the EUS is already fully spend or overspend, trade-offs only mean loss of time and continued exceedance of the CL. (Bastmeijer, 2018, p. 204). This perspective shows that the critical load for a particular environmental pressure should obtain serious attention in a programmatic approach, certainly if, as in the PAN cases, the critical load is far exceeded. We argue that the critical load of an environmental pressure like ND can also have a key role as “boundary object”[17] . The boundary object concept is applied in complex environmental problems and uses a cross-boundary indicator to communicate among the stakeholders in the problem. A boundary object is commonly accepted and understood by Politicians, Scientists and Society, helps to cross boundaries, and built trust in used data and proposed measures(Tuinstra, Turnhout, & Halffman, 2019, pp. 132, 133). We argue that the Critical Load of ND can be used as such a boundary object. However, the limited ambition level of the Dutch and Flemish PAN of 1% decrease in ND per year is a convenient ignorance of the critical load by politicians and society.

With regards to the challenging ecological monitoring in environmental governance, the case studies show the strong emphasis on the progress of the implementation of recovery measures rather than on the results and the effects of these measures. In a report by the Planbureau voor de Leefomgeving and Wageningen University & Research in 2020 about evaluative learning in national and provincial environmental governance, this type of monitoring is described as 1st order learning or optimization of the current approach (“are we doing the things right?”) rather than reflecting on the aimed ambitions and assumptions (2nd order learning or “are we doing the right things?”). The 2nd order learning is more challenging but leads to a more integrated strategy with better results (Folkert et al., 2020, p. 34). In the Dutch and Flemish PAN cases, the ecological improvements are mostly monitored by measurable indicators like number of recovery projects executed, or surface of new habitat created. These “lead” indicators aim to predict future results in ecological improvements that can only be measured by “lag” indicators after a long time. The relation between the 1st order learning (or use of Lead indicators) and the 2nd order learning (or use of lag-indicators) should be understood well in an effective Programmatic Approach. The lead

[17] Turnhout et al describe boundary objects as indicators that can represent nature and environment and link them to policy objectives. Critical loads are specific type of boundary object that can be used for a gap closure approach that was successful in Europe’s Long-Range Transboundary Air Pollution (LRTAP) convention.

indicators that are measured in a PA today should at least give a reasonable indication of the final success of the PA in a decade or later.

Despite the conclusion that the Dutch and Flemish PAN were not successful, the Dutch and Flemish PAN had many elements that could have helped to make them successful. In a study by the Flemish Research Institute Nature and Forest (INBO) in 2019 about the success rate of PA's, 11 INBO experts studied the preconditions of successful Programmatic Approaches and established a set of criteria. An independent scoring method was applied by the experts to score 38 different environmental pressures. The results show that three main criteria defined the success rate of a PA as instrument to balance and environmental pressure with economic development: (1) the knowledge about and understanding of the cause-and-effects throughout the DIPS(R) [18] model of the environmental pressure, (2) the importance of the environmental pressure, and (3) the complexity to implement the PA. Environmental pressures with clear understanding of cause-and -effects and thresholds obtained a higher success score, certainly if the sources for the pressures are specific and regional, and implementation of source measures is realistic (Herr, Quataert, Vanderhaeghe, Adriaens, & De Keersmaeker, 2019, pp. 39, 40). In the INBO study, the PAN is considered a typical example of a PA with a potentially high success rate because of the knowledge about ND and the possibility to take source measures. As example of an environmental pressure with a much lower success rate, the INBO experts describe the eutrophication by phosphor. This environmental pressure has "actually a large impact on the quality of habitat spots, but at the moment it is not possible to set-up a PA because of a considerable lack of information" (Herr et al., 2019, p. 40).
In an interview with L. De Keersmaeker [19], one of the INBO experts, we reflected on the implementation of the PAN. De Keersmaeker described two particular challenges: (1) the "shifting baseline" among farmers and in society in general and (2) the difficulty for the public to comprehend the devastating effects of the current intensive farming practices. The shifting baseline is described in the INBO 2020 Nature report as the continuously decreasing ambition level for biodiversity. Every generation considers the recent past as "normal" and this results in the ever-shifting perception about the loss of biodiversity as less and less urgent (A. et al., 2020, p. 8). When we transate the shifting baseline to the PAN cases, we can note that the aim of the PAN to "avoid further deterioration" is an example of the shifted baseline. With regards to the EUS ND theoretical framework in this thesis, the shifting baseline can be considered as the continuously contracting of the size of the EUS triangle. The other complication within society, according De Keersmaeker is the 'green' image that farming still has among the public. Even large monocultural fields with wheat or corn, that have the biodiversity of a desert, give a green impression to the public and are generally associated with nature. This complicates the public understanding of environmental problems like nitrogen deposition. (Personal communication, September 21st, 2022).

We conclude this thesis report with a recommendation for further study. The Dutch and Flemish PAN lead to annulment by court only a few years after they came into force. At the time of publishing this thesis report, the measures and thresholds for ND are still heavily debated between politicians, experts, scientists, environmental NGO's, industry, and farmers. With implementation of the PAN, the hard political choices that were needed to bring socio-economic activity in balance with conservation goals were postponed[20] and therefore the PAN was doomed to fail despite many good governance elements. The social and political discussions following the annulment of the Dutch and Flemish PAN, touch upon the core of the planetary boundaries problem and sustainable development process: who needs to change their ways to stay within the planetary boundaries? And how can politicians, supported by scientists, enforce the necessary measures while still giving perspective to the affected socio-economic actors? This fundamental question should be answered *as basis for* the establishment of a programmatic approach and not, like in the PAN cases, *afterwards*. Nitrogen Deposition is only one of many environmental pressures. Deforestation, habitat fragmentation, land dehydration, and chemical pollution are just a few examples of pressures that also need to be balanced with nature conservation goals and for which resistance from businesses will occur, like the post-PAN resistance by farmers. The analysis of the social and political discussions during the current "nitrogen crisis" can therefore give valuable insights in the way such a process could be facilitated to reach a commonly accepted basis for a Programmatic Approach.

[18] The DPSIR framework assumes a chain of causal links starting with 'driving forces' (economic sectors, human activities) through 'pressures' (emissions, waste) to 'states' (physical, chemical and biological) and 'impacts' on ecosystems, human health and functions,eventually leading to political 'responses' (prioritisation, target setting, indicators)(Food and Agriculture Organisation, 2022).
[19] Dr. Ir. Luc De Keersmaeker is forest ecologist at the Flemish Research Institute Nature and Forest (INBO) co-author of the publications on Recovery strategies (De Keersmaeker et al., 2018) and the study report on PA's (Herr et al., 2019)
[20] As can be illustrated by the famous judgements "niet alles kan overal" (Remkes, 2019), "Er mag niet meer op de pof worden geleefd als het gaat om het nemen van maatregelen die stikstofuitstoot reduceren" (Schouten, RTL news, 2019), and "Overheid en politiek zijn niet altijd de partijen geweest waar boeren van op aan konden, vooral omdat er te lang om de hete brij is heen gedraaid" (Remkes, 2022).

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