Is there a sustainable future for Dutch agriculture?

Navigating the nitrogen crisis: A comprehensive overview of the historical, current and future challenges faced by stakeholders of the nitrogen crisis

The fine balance between socio-economical and environmental interests

(Roach et al., 2022)

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Summary

The termination of the PAS, on the 29th of May, marked the beginning of the nitrogen crisis. A crisis that has both socio-economic and environmental impacts across various sectors including the agricultural sector in the Netherlands. This crisis has triggered significant unrest among stakeholders, leading to farmer protests and intense public debate. This paper explores how historical and regulatory developments in combination with stakeholder interests led to this nitrogen crisis and simultaneously aims to create public understanding. A chronological agricultural political timeline is constructed to provide an overview of the development of policies and practices that have shaped this crisis. The use of media and scientific sources enhances the complexity and emphasizes the interaction between policy regulations, actions, stakeholder dynamics, and environmental challenges, offering valuable insights into the broader implications for sustainable agricultural practices and policy formulation.

Since 1950, the economic growth, technological innovations, and the expansion of farms, resulted in an increase of agricultural production, fueled by the widespread use of nitrogen through fertilizers and manure. The Haber-Bosch Process accelerated this process, responsible for this boost in production. Nitrogen, a vital nutrient for plant growth also has a downside, excessive nitrogen losses lead to biodiversity loss and ecosystem dysfunction. Multiple policies and regulations have been implemented to mitigate the excessive nitrogen deposition.

Key findings highlight a significant shift in governmental and agricultural priorities from economic growth to environmental management over the years. The rapid implementation of policies and regulations has often overwhelmed farmers, contributing to widespread protests. Moreover, derogations allowing nitrogen deposition to exceed critical values have worsened environmental degradation. Despite efforts since 1950 to transition away from intensive agricultural practices, achieving this shift has proven challenging marked by policy failures. In summary, this research underscores the complex origins and impacts of the nitrogen crisis in the Netherlands, emphasizing the need for balanced policy approaches and sustainable agricultural practices to mitigate environmental damage while supporting economic viability. Where effective public understanding is crucial for successfully implementing these balanced policies concerning nitrogen deposition.

Table of contents

1. Introduction

"Halving the livestock? A reduction of 90 percent is merely a good start" – TROUW (Lambers, 2023)

This headline was prominently displayed on the front page of the Trouw newspaper in 2023, capturing the impact of the ongoing Nitrogen crisis and its effect on farmers. According to the website ZLTO (2020), farmers are portrayed as "a professional group that would stand directly opposed to nature". Reflecting how the role of farmers is often portrayed to society. However, Giller (2021) describes in his paper on 'The future of farming: Who will produce our food?', that the aim of farmers is to provide nutritious diets for humans and animals, while sustaining the livelihood of farmers and their employment stability, and maintaining the balance of ecosystems and natural earth processes. Farmers play the main role in agriculture and are seen as a core economic sector and have the potential to induce worldwide sustainable economic growth in the Netherlands. Currently, Dutch farmers are the central figures in ongoing debates and conversations regarding the fine balance between ensuring global food security for a larger and wealthier population while maintaining biodiversity and ecosystems.

According to recent data from the Central Bureau of Statistics (2024), a significant quantity shift has occurred in the agricultural sector since 1950 in the Netherlands. Notably, in 1950 there were 410,000 registered Dutch farms, whereas by 2020, this number decreased to only 53,000 as can be seen in Table 1.

Table 1: Perspective of growth in the Netherlands, data of Central Bureau of Statistics (2024)

	1950	**Now**
Population	10 million	17.4 million
Amount of cows	1.57 million	1.6 million
Amount of farms	410,000	53,000
Ammonia emission	333 kilotons	110 kilotons
Amount of cars	140,000	8.9 million
Passengers at Schiphol	350,000	58 million

Since 1950, farmers have been encouraged to expand their businesses and increase production capacities, leading to a decrease in the number of farms due to scale enlargement. The increasing world population in combination with economic growth and technological innovations after World War II,

resulted in significant growth of agricultural production and an increase in anthropogenic Nitrogen production (Alexander P et al., 2017).

The worldwide production of food accounts for approximately 25 percent of the worldwide greenhouse gas emissions (Vermeulen et al., 2012). The Netherlands contributes to this as the world's second-largest exporter of agricultural products, with agricultural land use covering 49 percent of the total land area (Ro, 2024; CBS, 2022). To enhance crop yield to maximize profits for farmers and facilitate fast and efficient production, large amounts of fertilizer and manure are utilized. The Dutch agricultural system is famous for its efficiency, characterized by a large livestock population, significant imports of animal feed, intensive land use, high production levels, and a high export value (Van Grinsven & Van Eerdt, 2020). To sustain this high-efficient system, nitrogen (N) is crucial, as it is the fundamental element necessary for the production of both plant and animal products (Follett & Hatfield, 2001).

While the Dutch agricultural food production achieves high production levels, it simultaneously faces socio-economic and environmental issues (Schoop, 2024). Nitrogen, a vital nutrient essential for life also has a downside, it can act as an insidious pollutant (Erisman et al., 2015). Excessive nitrogen deposition caused by high livestock density and fertilizer and manure applications (Schoop, 2024), poses an ongoing problem in the Netherlands. With the Netherlands even recognized as the greatest nitrogen emitter in Europe causing and affecting biodiversity and ecosystems negatively (Erisman et al., 2001).

The excessive nitrogen losses disturb aquatic, air, and soil systems, and interrupts the natural nitrogen biogeochemical cycle, decreases soil fertility, biodiversity and leads to the aggravation of the greenhouse effect, and has direct impacts on humans via the contamination of drinking water (Qiao et al., 2015). To mitigate these off-field nitrogen losses, the Dutch government has implemented and still is implementing measures across the industry, agriculture, transport, and construction sectors to decrease nitrogen deposition to improve the quality of natural areas and combat climate change (Giller K. et al., 2021). In 2015, the government introduced the Programma Aanpak Stikstof (PAS), to enhance nature while simultaneously facilitating economic development (Van Dreumel-Wingens, 2015). However, on the 29th of May 2019, the Dutch Council of State (i.e. Raad van State) stated the PAS null. This moment is also called the beginning of the ‘Nitrogen Crisis’, which plays an important role in public debate and policy in the Netherlands and led to socio-economic issues and stimulated heated emotional discussions (Appl, 2011). The PAS judgment in 2019 resulted in the harsh suspension of numerous projects across various sectors, including residential construction, road infrastructure projects, airport expansions, and agricultural production (Stokstad, 2019). This had large consequences and led to

a state of paralysis within the country, as noted by Jeroen Candel, a political scientist at Wageningen University and Research. Managing nitrogen emission has proven to be challenging, as it comes from diverse sources; agriculture, industry, construction, and transportation, illustrated in figure 1 (Erisman et al., 2001). Consequently, while the nitrogen crisis affects the whole country, it is imperative that the nitrogen crisis causes unrest among all stakeholders, including the public, industry, policymakers, and producers, who are faced by the challenges arising from the excessive deposition of nitrogen. Among the contributors to nitrogen emissions, farmers have emerged as central figures in the crisis, the so-called 'peak polluters', illustrated in figure 1.

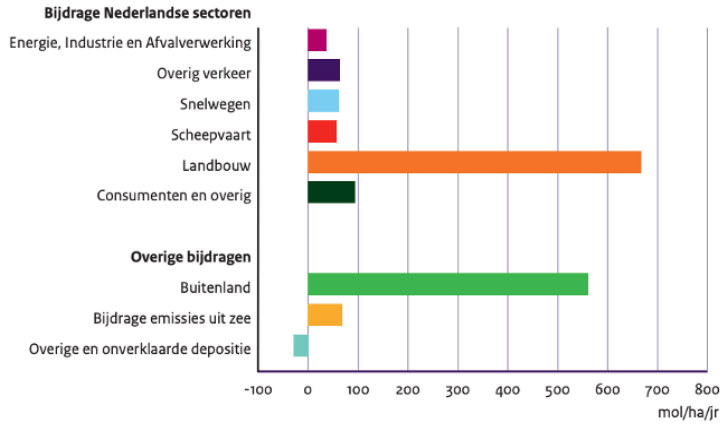

Figure 1: Average nitrogen deposition in 2014 in the Netherlands on nitrogen-sensitive habitat types and habitats for species in Natura 2000 areas (RIVM, 2021)

The nitrogen crisis represents only a small part of the broader, ongoing complexity in Dutch agriculture, having both socio-economic and environmental impacts. Therefore, to fully understand the nitrogen crisis, this paper will investigate the changing roles and interests of various regulations and stakeholders over the past 70 years. Furthermore, it analyzes the impact of the regulations on farmers and explores the challenges of balancing the economic necessity of agriculture with the imperative of environmental sustainability and sheds light on current solutions. In light of this, the following research question emerges, and other supporting subquestions:

How did historical and regulatory developments in Dutch agriculture and stakeholder interests lead to the nitrogen crisis?

1. What are the historical developments in Dutch agricultural regulations and the measures proposed to mitigate nitrogen emissions over the past 70 years?
2. What viable pathways remain for farmers within Dutch agriculture to reduce nitrogen emissions, considering the various measures and subsidies proposed over the past 70 years?

3. What is the impact of these regulations on farmers?
4. How did the interest of governmental bodies and farmers change over time?

These questions aim to enhance public understanding by providing an overview of Dutch agricultural history and the complexities of the Dutch nitrogen crisis. Through literature research, these questions will be addressed through examining historical regulations, policy changes, environmental studies on nitrogen pollution, and public debates and media representations. The study aims to determine truths from misconceptions and explore the challenges of the nitrogen crisis. There is a pressing need for research to fully understand the underlying political historical dynamics of the nitrogen crisis and its impacts, to combat the negative effects of nitrogen.

2. Theory

This section provides clarification of used terms and the theoretical foundation on which this paper is based.

2.1 The Role of Reactive Nitrogen in Agriculture

While N_2 itself is not harmful, its conversion to a reactive form and accumulation of excessive amounts can lead to environmental problems. In this research, nitrogen is referred to as reactive nitrogen including all forms of reactive nitrogen except the N_2 molecule. Reactive nitrogen is transported through air, water, and soils and has direct effects on ecosystems (Holmes et al., 2019). Organisms can only utilize nitrogen in its reactive state (Holmes et al., 2019). Reactive nitrogen comprises NHx, composed of ammonia (NH_3) and ammonium (NH_4+), as well as NO_x, which consists of nitrate (NO_3-) nitric oxide (NO), nitrogen dioxide (NO_2), and nitrite (NO_2-) (Follett & Hatfield, 2001; Galloway et al., 1995). Where NO_x and NH_3 pose the ongoing problem, and further referred to as nitrogen.

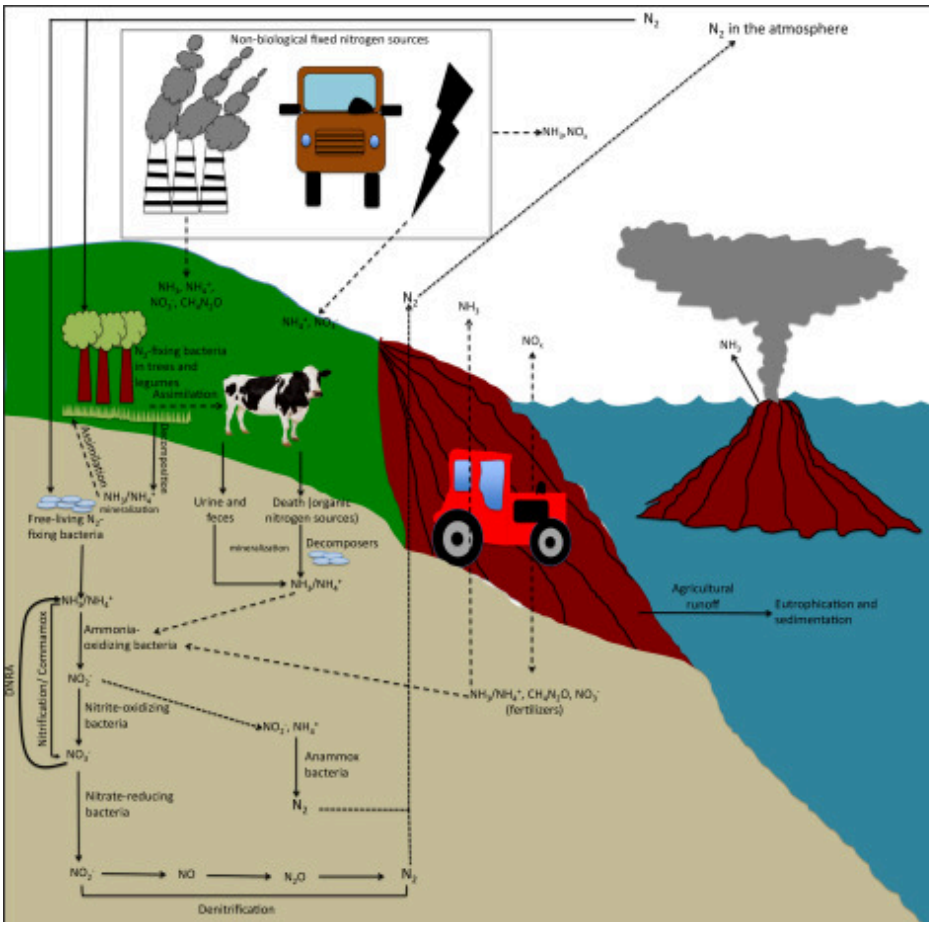

Figure 2: Nitrogen cycle (Holmes et al., 2019)

Nitrogen fixation, illustrated in the nitrogen cycle in figure 2, is the process where N_2 is transformed into forms of reactive nitrogen (Hanrahan & Chan, 2005). This process occurs through biological processes and non-biological processes including, combustion, lightning, industrial fixation, burning of biomass fuels, and deforestation. Non-biological activities have significantly increased the input of nitrogen into the environment (Holmes et al., 2019).

2.1.1 Nitrogen as fertilizer

Nonetheless, nitrogen is one of the elements that is necessary for good plant growth (Leigh, 2004). In the 20th century, the main sources for fertilizers were niter and guano extracted from tropical islands, yet these proved insufficient. To meet the production growth, Nitrogen (N) emerged as an ideal alternative due to its cheap abundant availability, stability, and lack of reactivity. Nitrogen was available through the Haber-Bosch process and the import of animal feed and manure from developing countries (Erisman et al., 2005). The Haber-Bosch Process was introduced, shown in Formula 1; it is known as the primary industrial method for producing ammonia, which nowadays, serves as the main source of fertilizers (Appl, 2011). This process ensured a fast increase in the agricultural industry and is known for its affordability and efficiency. As this process ensures the rapid production of large quantities, it also has disadvantages as it does require a lot of energy.

$$N_2 + 3H_2 \Leftrightarrow = 2NH_3$$

Formula 1: The Haber-Bosch Process

Approximately 94% of ammonia is produced through agricultural systems, primarily from animal manure, beneficial for boosting the biological diversity of the soil. The excretion of manure, leads to a supply of nitrogen and phosphate to the environment. High production as a result of high livestock density resulting in significant environmental issues such as acidification and eutrophication (Schoukens, 2018; de Vries, 2021).

2.2 Environmental impact of reactive nitrogen

Nitrogen is denoted as the main contributor to environmental pollution from Dutch Agriculture, leading to global warming, biodiversity loss, change of land use, eutrophication of water, and ocean acidification (Erisman et al., 2005). Since the Industrial Revolution fertilizers became indispensable, accelerating the demand for ammonia in fertilizer use. The high livestock density in combination with the use of manure, derived from organic matter, and fertilizers, synthesized from artificial substances, where manure consists of fewer elements compared to fertilizers, both providing rapid growth and

increase of soil fertility, leads to significant environmental issues following intensive Dutch agricultural practices (Sharpley et al., 1987).

The overabundance of reactive nitrogen disrupts the global nitrogen cycle. In agricultural practices ammonia is released through the combination of animal manure and urine leading to an excessive amount of nitrogen (Levitt, 2021). Losses of nitrogen occur through run-off and leaching as not every nitrogen product can be effectively absorbed by soil, water, or the atmospheres. The losses arise before plants can even utilize the minerals (Qiao et al., 2015).

Soils unable to absorb fertilizers, cannot ensure crop production leading to acidification of the oceans and eutrophication of freshwater bodies caused by leaching and runoff from fertilizer of agricultural land. The absorption is dependent on the application method, used fertilizer and the crop type (Ayoub, 1999). Additionally, excessive reactive nitrogen input leads to soil fertility loss and poses a risk to food production and biodiversity. Furthermore, each plant species has varying thresholds for nitrogen tolerance until negative long term effects occur. When an area experiences losses of species, it can result in a decline in ecological functionality (PAS, 2015).

2.3 Definition of agriculture

Overtime, the general definition of farming and agriculture has changed. Around the 1950s people described it as: “The application of labor in combination with capital to nature, to let it produce more useful plants and animals than it would produce without any interference” or as “the human activity that produces useful organic material using plants and animals, with the sun as the source of energy”. In the end, the all-encompassing definition of agriculture is defined as ‘Applied ecology’. This includes the essence of trying to control biological processes (Astill & Langdon, 1997). Applied ecology can thus be interpreted in different ways, around 1950 a shift in the methodology of farming occurred.

2.4 History of Dutch agriculture

The Netherlands is regarded as one of the leaders in agriculture in Europe. This is due to three reasons. Firstly, the suitable Dutch climate. Precipitation does not fluctuate too much over the year, providing optimal growing conditions. Secondly, the geographical location at the North Sea, where the Schelde, Maas and the Rijn flow, serves as the trade center of Europe. Stimulating the population to commence with various sorts of agricultural activities in different forms. Thirdly, the Dutch farmers are recognized as pioneers in agriculture, as they introduced technological advancements from early centuries on. The use of the soil plough with horses, introduced in the 11th century, provided fertile soils and increased agricultural productivity (Veerman,2020).

Once the population started to grow and economic-well being improved, people realized that there were limits to growth (Cooper & Cohen, 1996). Fertilizers have been extensively used to enhance agricultural yields, the introduction of the Haber-Bosch process (Formula 1), generating large amounts of fertilizer, combined with animal manure, resulted in a boost of agricultural production in the Netherlands since 1950. Globally, the use of fertilizers has increased from 46 million tonnes around the 1960s to 130 million tonnes in 1990 (Ayoub, 1999). Dutch agriculture followed this trend, this is shown in figure 3.

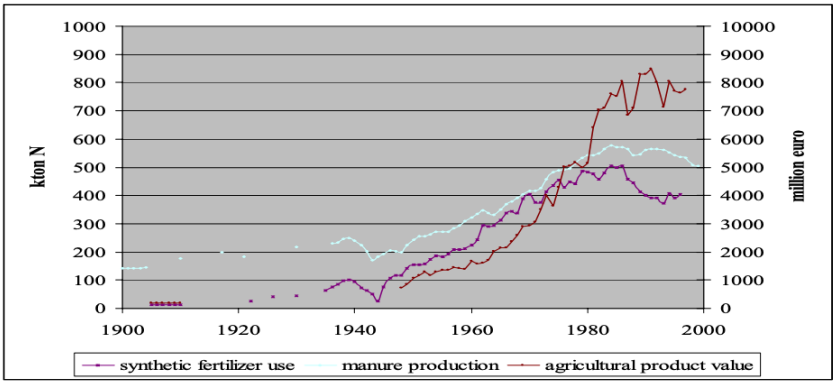

Figure 3: Development of dutch manure production (Erisman et al., 2005)

The trend of increasing livestock density in the Netherlands has continued to rise compared to other European countries. Dutch agriculture is characterized by high livestock density, illustrated in figure 4, which is a major factor contributing to the high overall nitrogen deposition (Veerman, 2020). This density has led to increased manure production, and, along with the rise in synthetic fertilizer use around 1950, has caused significant environmental issues. Including desertification, deforestation, pollution of aquatic systems, species loss, global warming, and rising seawater levels (Frink et al., 1999).

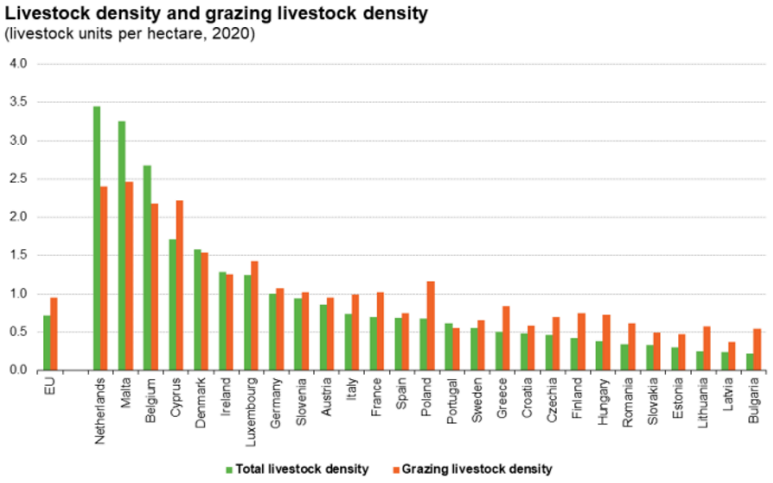

Figure 4: Overview of European livestock density and grazing density in 2020 (Eurostat, 2023)

Natura 2000 network

In 1979 the Bird Directive, complementing the EU Habitat Directive, led to the establishment of the EU Natura 2000 network in 1992. The Natura 2000 network in the Netherlands consists of 162 natural areas designed to preserve threatened species and habitats (Ministry of Agriculture, Nature and Food Quality, n.d.). Member states of the EU determine which areas are included in the Natura 2000 network, but they must comply with the regulations of the Birds and Habitats Directives (Kokkoris et al., 2023). Figure 5 illustrates the Natura 2000 areas and highlights the regions where nitrogen deposition exceeds the critical load values (purple). The maximum critical load is defined as the amount of nitrogen deposition that intact ecosystems in the Netherlands can tolerate over a longer period without having significant damage to its functioning (RIVM, 2019), this amount varies between 5 and 25 kg nitrogen per ha per year (Wageningen University & Research., n.d.).

Figure 5: Map of the Netherlands showing the exceedance limits of the critical nitrogen deposition values, >1400 moles/ha/year is exceedance amount of the critical Load of Nitrogen (RIVM, 2019)

2.5 Stakeholders Dutch agriculture

The nitrogen crisis impacts many different stakeholders. Note that not every party is taken into consideration for the scope of this research. Key ones are mentioned in figure 6 and further described in Table 2. The interplay between these stakeholders, including scientists, government bodies, farmer organizations, activist groups, and consumers, shapes the policies and actions taken to address the nitrogen crisis in the Netherlands. Understanding their roles and influences is crucial for developing effective solutions and gaining a comprehensive understanding of the nitrogen crisis and agricultural

history. It is of great importance to be aware that roles, responsibilities, and interests of stakeholders change over time.

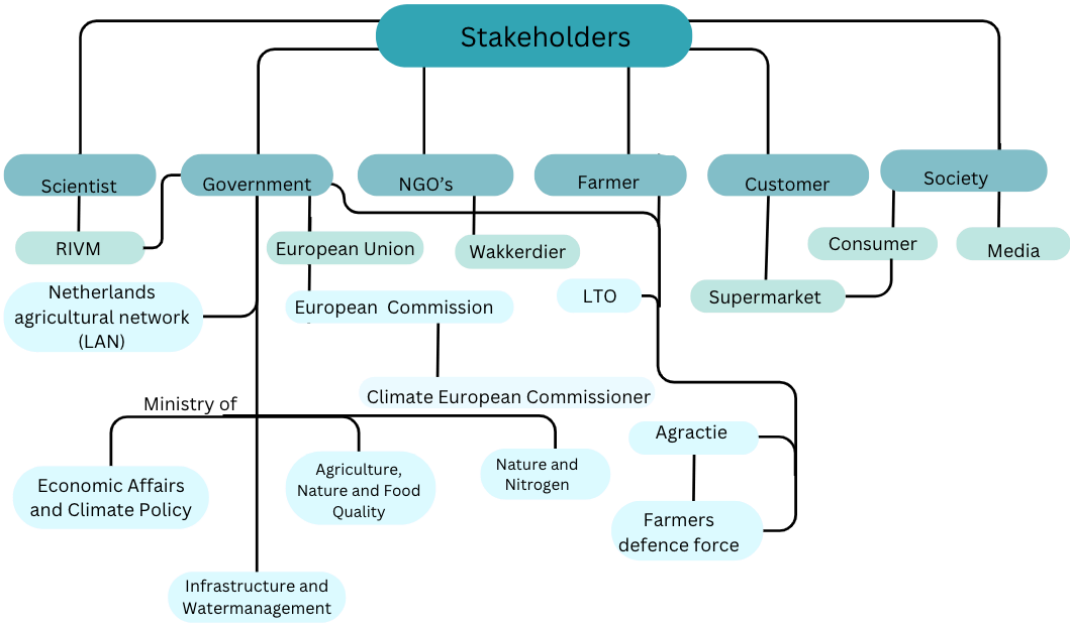

Figure 6: Overview of stakeholders of the Agricultural Crisis (Selnes, 2023)

Starting with scientists, their role in the nitrogen crisis is pivotal. The crisis began due to an excessive amount of nitrogen, which was accurately measured by scientists, especially from the RIVM, that brought the issue to light. Without their ability to measure and quantify the nitrogen levels, the negative effects of the excess nitrogen would have not been known, thus making it crucial for understanding and addressing the crisis.

The second key actor is the Dutch government, playing a significant role in Dutch Agricultural policies, assisted by different ministers (Table 2). Also, the Dutch Agricultural Network (LAN) is established to achieve and attain the sustainable development goals (SDG) (LAN, 2023). According to Berkum and Dengerink (2019), Dutch policies related to agricultural practices emphasize on achieving SDG 2, zero hunger, while simultaneously aligning closely with the other 16 SGDs. The policy objectives aim to enhance productivity, ecological sustainable use of resources, and improved food security.

Table 2: The role and interests of stakeholders concerning the nitrogen crisis (Selnes, 2023)

Stakeholder	**Role**
National Institute for Public Health (Rijksinstituut voor volksgezondheid, RIVM)	Responsible for mapping the emission of nitrogen in the Netherlands (RIVM, 2024).
Dutch Agricultural network (LAN)	Supports Dutch agricultural companies over 80 different countries.
The Ministry of Infrastructure and Water Management	Supervises environmental policies about infrastructure and water.
The Ministry of Agriculture, Nature, and Food Quality	Is relevant for the whole agricultural planning.
The Ministry of Nature and Nitrogen	Regulates nitrogen emissions in the Netherlands.
Climate European Commissioner	Ensuring the implementation of the European Climate Law (EU, 2023).
European Union	Creating overarching regulations and policies aimed at reducing nitrogen emissions and setting emission reduction targets across Europe.
European Commission (EC)	Responsible for monitoring the implementation of European legislations and proposing them, consisting of 26 member states and is led by one president (EU, 2023).
Wakkerdier	An independent foundation fighting for animal welfare through organizing campaigns.
LTO (landbouw en tuin organisatie)	Promotes a favorable business environment for farmers in the Netherlands and Europe (LTO, 2024).
Farmers	Provide nutritious diets for humans and animals while simultaneously sustaining the livelihood of farmers and the balance of ecosystems and natural earth processes (Gillers, 2021).
Agractie	Activist organization representing farmers through telling their stories and spreading them via different sources (Agractie Nederland, 2023). .
Farmers Defense Force (FDF)	Activist organization representing 35,000 farmers, advocating for circular agriculture, for economical and societal relevance, work with experts in the field of agriculture (Stokstad, 2019).
Supermarkets	Are responsible for what products they purchase and what they offer the consumer.
Consumer	Are responsible for what products they purchase and eat.

From table 2, it is evident many stakeholders influence each other. An example of this is the role of consumers. They play a significant role in the food chain by influencing farmers through their purchasing decisions (Alexander P, et al., 2017). When consumers want to pay less for products, supermarkets, acting as intermediaries, are compelled to lower their payments to farmers. Consequently, farmers receive reduced earnings, highlighting the indirect impact consumer behavior has on agricultural economics. Also they play a critical role in reducing nitrogen emissions. A significant dietary shift is necessary; reducing livestock without altering beef consumption patterns will only lead to increased imports, failing to address the problem effectively. According to Petermann (2023), the number of vegetarians is not expected to rise proportionately with the growing population, making this dietary shift challenging to achieve. Consequently, change in consumer behavior and dietary patterns are essential to mitigate nitrogen emissions.

In addition to consumers, the media plays a crucial role. The media reflects social structures, power relations and dynamics, and ideological beliefs in society, influencing public perception and policy decisions (Melissa N.P. Johnson & McLean, 2020). However, this paper particularly emphasizes the roles of farmers and the government in understanding the evolution of nitrogen reduction strategies and their practical implications and to answering the question of how the interest of governmental bodies and farmers changed over time.

3. Methods

The aim of this paper is to provide transparency and a comprehensive understanding of the complexity of the nitrogen crisis. This is framed within the research question: How did historical and regulatory developments in Dutch agriculture and stakeholder interests lead to the nitrogen crisis? To address this question, a literature review has been conducted, utilizing a narrative approach, while synthesizing a broad range of information to understand the historical and policy context of the origin of the nitrogen crisis in Dutch agriculture.

3.1 Literature review and data collection

To acquire relevant literature and to enhance transparency, it is decided to use different news sources, the media, youtube videos, scientific papers, newspapers and governmental websites, as outlined in Table 3. Also, to ensure comprehensive coverage of relevant topics, different search terms are used:

Dutch agriculture, Agricultural history, agriculture, agricultural policies, governmental regulation, CAP policy, nitrogen regulation, manure regulation, sustainable agriculture, ecological management, dairy Act, Mansholt plan, Milk Quota, Dutch Government, European Commission, LTO, Farmer Defense Force, media impact, RIVM, Supermarkets, Agractie, nitrogen pollution, impact environment, manure, fertilizer, agricultural economics, farmer livelihoods, socio-economic impact, consumer behavior, nitrogen mitigation measures, agricultural subsidies.

3.1.1 Use of Dutch sources

Both English and Dutch sources are utilized in this research to explore the complexities of Dutch agriculture and the nitrogen crisis. Dutch media sources and newspapers are valuable for providing context-specific information relevant to the Netherlands. Also through using local sources, the nuances and expressions are captured and cultural understanding is incorporated. Furthermore, local sources often contain more precise and detailed data, including historical documents and records related to Dutch agricultural practices and environmental policies, many of which are available only in Dutch. Utilizing these sources ensures a thorough understanding of the historical developments that have led to the current situation. Additionally, delving into Dutch media and newspapers enhances transparency and offers a realistic view of the ongoing issues, enriching the research with diverse perspectives and up to date information.

Table 3: Source selection

Sources	**Entails**	**Retrieved from**
Scientific papers	Peer reviewed articles and academic journals	Google Scholar, WUR
Governmental websites	Official reports and document from Dutch government agencies	RIVM, Rijksoverheid, CBS
Media sources	Used as a database to investigate the public opinion. Media sources include interviews and opinion articles that reflect the views and experiences oflocal stakeholders.	Twitter, Facebook, Instagram, YouTube, BNNVARA, NOS, VOX
Newspapers	Information on different events with a certain impact	Eenvandaag, Trouw,
Other sources (books and other publications)	Various sources	Online Elsevier Ebooks

3.2 Analysis of historical timeline and current policies

This data collection is integrated into a historical timeline, highlighting the most significant regulations, policies, and events impacting Dutch agriculture as imposed by the government. Focusing on these policies and regulations is essential, as they have heavily influenced the nitrogen crisis. According to energy scientist Remco de Boer (2018), understanding the history of the current situation is crucial for shaping political transitions. This approach aims to clarify the complexities faced by farmers and policymakers, providing a comprehensive context for addressing the ongoing crisis.

The timeline begins in 1950, marking the start of the modern agricultural system (Karel, 2010). The timeline is based on the video of Lubach (2019), discussing the farmers' protests and the underlying issues in the agricultural sector in his video “70 years of Dutch agricultural policy”. This narrative explains valuable context for understanding public sentiment and media representation of the crisis forms the main structure for the first part of the research in combination with the historical timeline of the Common Agricultural Policy (CAP), from the European Council (n.d.). Throughout the timeline, empirical data is added. Interests and opinions of stakeholders of the agricultural crisis are incorporated, primarily focusing on the government and farmers, who are often seen as opposing parties. While other actors will be discussed, the emphasis will be on these main stakeholders.

Secondly, the current policy instruments and measures are investigated to answer the question of what viable pathways remain for farmers within Dutch agriculture to reduce nitrogen emissions, considering the various measures and subsidies proposed over the past 70 years?

4. Agricultural politics over time

This timeline illustrates the challenges faced by farmers in Dutch agriculture over the past 70 years, highlighting the fine balance between environmental and economic interests and the ongoing evolution of Dutch agricultural policies shaped by different political measurements, regulations and major events. This chapter simultaneously answers the question; What are the historical developments in Dutch agricultural regulations and the measures proposed to mitigate nitrogen emissions over the past 70 years?

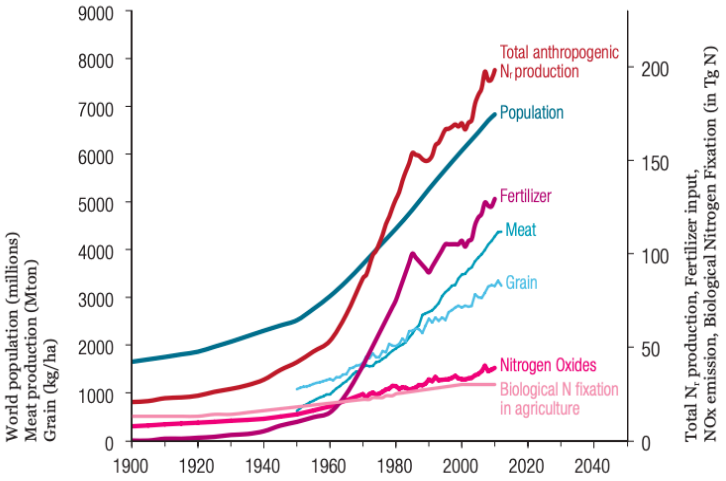

Figure 7: Global trends of nitrogen anthropogenic activities and world population (Erisman et al., 2015)

1950 - The dawn of agricultural cultivation

After the introduction of the Haber-Bosch process (Formula 1), the 'green revolution' commenced (Erisman et al., 2015). This resulted in an increase of nitrogen use 3.6 million tonnes of nitrogen in 1950, towards 85 million in 1990, responsible for a tremendous increase in food production, illustrated in figure 7 (Ayoub, 1999). This also shows that the Dutch farmers followed the same trend as what was globally seen.

In 1950, following World War II, the reconstruction of the agricultural sector was in full progress. Sicco Mansholt, minister of agriculture from 1945 to 1958 and subsequently in 1958 European Commissioner for Agriculture, established minimum prices for nutritious products after World War II to prevent food shortages (Europese Unie, 2023). Prior to this, farmers were conservative with farm growth and

production being limited, and farming practices remained traditional, often passed down from father to son, like family businesses. It was not beneficial to try new techniques when old habits still proved to be sufficient. However, to be able to compete on the international market again, achieve profitability, and feed the growing population, intensification was necessary. This led to the urgent need for the adoption of new innovations and insights in agriculture and a structural improvement of the system (Karel, 2010).

1954 - Reshaping the landscape for efficiency

A significant structural problem in Dutch agriculture was land fragmentation. Each farmer owned small, diverse plots of different types of land. It was believed larger fields would be more efficient and increase food production. The transition to simplified agricultural landscapes led to reduced biodiversity, ecosystem services, and habitat space which are crucial for the resilience of agricultural production. Furthermore, ecosystem services and habitat availability are provided through diverse landscapes (Schiller et al., 2024). Nonetheless, the economic benefits of consolidation outweighed the environmental consequences. The Land Consolidation Act of 1954, facilitated land development and the acceleration of efficiency rates.

1962 - Stability through the CAP

In 1962, the Common Agricultural Policy was introduced. Driven by multiple post-World War II issues: insufficient food production, extremely low farmer incomes, and imbalanced national agricultural policies that resulted in competitive inconsistencies. The CAP aimed to increase agricultural productivity, secure the food supply, and stabilize the market. It provided farmers with an income guarantee by maintaining high international prices for agricultural products. Nowadays, the CAP has deliberately implemented instruments to contribute to a better environment (Pe'er, et al., 2019).

1970 - The Mansholt Plan and the disappearance of small farms

Mansholt observed that the livelihood of farmers did not improve significantly after the implementation of the CAP. In 1970, the Mansholt Plan was introduced, aiming to reduce the number of small farms and abolish subsidies for unprofitable farms. This led to a large demonstration in Brussel on the 23rd of March 1971, as farmers felt threatened in their existence. Small farms merged to form larger industries, to sustain a more feasible average income for farmers (Council of the European Union, n.d.).

1984 - Tackling overproduction with the Milk Quota

Hereafter, Dutch agriculture was improving in both productivity and efficiency, however, this led to extreme production surpluses, with terms like 'buttermountain' and 'milk lake' commonly used to denote the excessive production of milk and butter. In 1984, the Milk Quota policy was established.

This policy restricted the amount of milk that could be produced, assigning each farmer an allowed production quantity. If a farmer exceeded this limit, they were required to pay an amount of approximately 0.56 cents per Liter of excess milk. The policy was initially intended to last for a period of 5 years, but remained in effect until 2015 (Klootwijk et al., 2016). In 2011, the milk production exceeded the established limits, resulting in a fine from the European Commission of approximately 17 million euros (ECER, 2018).

1985 - Introduction of environmental concerns

Around 1984, it was noticed that the excessive use of nitrogen and phosphorus in fertilizer, led to the contamination of aquatic systems (Sharpley et al., 1987). In combination with the large over productivity and efficiency, the Dutch Manure and Fertilizer Act was introduced in 1987 to reduce nitrogen and phosphorus losses. This regulation specifies permitted amounts of fertilizer and animal manure on grasslands, and arable lands (Grinsven &Bleeker, 2017). It was in 1985 that a shift occurred in agricultural policies from agro-economic development to environmental concerns (Erisman et al., 2005).

1987 - Recognition of the impact of manure

The first Manure Act was established in 1947 with the intention of running a smooth manure trade and focused on economical aspects. The manure legislation set up in 1987 by the Dutch Minister of Agriculture of Nature and Food Quality arose from environmental concerns and has determined nitrogen use standards (Van Grinsven & Van Eerdt, 2020). It is allowed to emit a maximum of 170 kilograms per hectare of agricultural land area belonging to the company, this quantity is laid down in article 10. Also, a maximum of 11,3 milligrams of nitrogen per Liter in sweet waters, for groundwater it is 50 milligrams of nitrate (N). Violation of these standards, result in a ban on fertilizer use on or in the soil for a calendar year according to Article 8. b. The introduction of the Manure and fertilizers act resulted in more complexity, for ministries, state secretaries, and every involved agricultural representative (Van Grinsven & Van Eerdt, 2020).

1988 - Environmental concerns are taken serious

Another significant turning point in the history of environmental awareness and shift in agricultural policies, is the introduction of the Zorgen Voor Morgen (Worries For Tomorrow) report from the RIVM. Which was the crucial first start of the National Environmental Policy plan and considered as the first drastic political call that the reduction of greenhouse gas emissions was considered a high priority (RIVM, 2013).

1991- Nitrogen is defined as the enemy

The consequences of the intensification of agriculture on the environment became even more visible. To put a brake on the excessive amount of nitrogen leaching, the European Nitrates Directive was introduced in 1991. This entails a permitted use of N of 170 kilograms of animal manure per hectare. However, the Netherlands managed to receive a derogation from the European Commission to utilize more than this limit under a specific condition; a phosphate limit of 172.9 million kg/yr for the entire Dutch livestock sector (Klootwijk et al., 2016). This is a step back for the upcoming environmental urge. The derogation ensured that some Dutch farmers were still allowed to spread more manure than legally was allowed.

1992 - Mac Sharry reform and CAP reformation

Right after this, the Mac Sharry reform was introduced in 1992 in the reformation of the CAP by the European Commission, commencing a shift in price support (LEI- LDO, 2019). The aim was to decrease the pressure on the rising costs of agricultural products in the export market. To avoid large income losses, subsidies were given to farmers by direct payments on the basis of land area and the quantity of animals. In 2003, the Mac Sharry reform was further developed, providing income support without the requirement of farmers to produce specific goods (OECD, 2011).

1998 - Innovations in the management of nitrogen

In accordance with the European Nitrates Directive, the mineral accounting system (MINAS) was introduced in 1998. Companies were obliged to report their phosphate and nitrogen use. A new step forward in environmental policy making as it resulted in a decrease of inorganic fertilizer use in the agricultural sector resulting in the reduction of nitrogen surplus (Erisman et al., 2005).

2015 - Liberation day for farmers

First of April is seen as liberation day for Dutch farmers, as the Milk Quota is suspended in response to the increasing global milk demand, hindering the progress of developing countries (Klootwijk et al., 2016). In an article of the news source NOS with the headline “The Netherlands will soon conquer the dairy world”, dairy farmer Niek Konijn states: “This gives a farmer more room to do business. If you do it correctly, your company can grow significantly. With almost doubling the amount of cows in the coming years’’ (NOS, 2015). However, according to the newspaper Eenvandaag, there is also fear among people that this will result in an uncontrolled growth and the fear for the origin of ‘cowflats’ and ‘manure mountains’ is what is stated in the article ‘abolition of the milk quota, end of an era’. (EenVandaag, 2015).

2015 - The dairy act sets limits

Three months after liberation day, many farmers were unexpectedly confronted with the Dairy act. To provide an answer on what the impact of the regulations is on farmers, Agractie, a Dutch activist organization, highlights the following; “Agriculture in the Netherlands is constantly changing. Farmers have experienced increasing pressures over the past years, in which social demands and regulations seem to be coming at them at an increasing pace” (Agractie Nederland, 2023).

After the abolition of the MINAS, the Netherlands still had to comply with the Nitrates Directive, and the Dutch government introduced a new manure policy. In 2015, the Dairy Act was enacted to support the growth of the Dutch dairy sector while also limiting increases in phosphate production (Klootwijk et al., 2016). This set maximum limits on the application of nitrogen from animal manure and nitrogen fertilizer, as well as phosphate fertilizer, per hectare of land. The limit was set at 170 kg N emission per hectare per year (Van Grinsven & Van Eerdt, 2020). With the goal of preventing exceeding phosphate production limits while simultaneously promoting growth in the dairy sector without crossing the environmental thresholds (Klootwijk et al., 2016). However, farmers holding a derogation are permitted to use up to 220 kg of N per hectare of land.

2019 - The beginning of the Nitrogen Crisis

In 2015, the Government introduced the nitrogen approach program (PAS). To enhance nature while simultaneously facilitating economic development (Van Dreumel-Wingens, 2015). According to Figure 1, agriculture has the most impact on nitrogen deposition in Natura 2000 areas. The PAS aimed to reduce nitrogen emissions affecting 118 Natura 2000 areas and habitats while balancing economic development and the conservation of Natura 2000 areas. A system created for nitrogen licensing, structured around future reductions in emissions, allowed the start of new economic activities around Natura 2000 areas (Selnes, 2023). However, The PAS violated EU law, as it mainly focused on future emission reductions, allowing current nitrogen emitting projects to continue without ensuring a long term nitrogen level decrease (RIVM, 2019). On May 29, 2019, the Dutch Council of State (i.e. Raad van State) stated the PAS null. This moment is also called the beginning of the ‘Nitrogen Crisis’(Stokstad, 2019). Having large consequences for the whole society and every sector in The Netherlands including; agriculture, industry, construction, and transportation (Erisman et al., 2001).

2019 - Farmers protest

To comply with EU nitrogen pollution limits, the Netherlands must reduce its livestock and the number of farms, leading to significant protests from farmers and activists (POLITICO staff, 2024). On June 1 in 2019, the Farmer Defence Force took action by occupying a pig farm in Boxtel. This move was met with disapproval from animal protection organizations and the Minister of Agriculture, Nature, and

Food Quality, as it disrupted their daily activities.Not long after the occupation of the FDF, on October 1, Agractie and the FDF organized a protest in The Hague against these nitrogen regulations. The founder of FDF said in an interview during the protest: “No livestock should be surrendered, the farmers want decent crop protection products and good nitrogen measurements.’’ (NOS, 2019).

2021 - A new era for the CAP

The European Commission's analysis examines the impacts of the Common Agricultural Policy on the sustainable management of natural resources in the EU stating the following: “The new CAP takes further steps towards a fairer distribution of income support and a greater targeting towards small and medium-sized farms” (European Commission, 2021). The CAP proposes to improve the quality of the soils and agriculture, and is required to utilize crop rotation. Furthermore, farmers have to assign 4 percent of their land to non-productive features to enhance the improvement of biodiversity.

2024 - BBB demands for agricultural derogations in Brussel

The Dutch coalition of 2024 set to form the new government, aims to retain nitrogen derogations and moderate manure and nature regulations. The BoerenBurgerBeweging (BBB) party, focused on preserving the agricultural sector and small farms, is actively involved. In May 2024, Caroline van der Plas, chairperson of the political party BBB, requested the Euro Commissioner in Brussels to allow for a more flexible regime for manure use (ANP, 2024).

This is an example of one of the hopeless actions taken to postpone the problem and not face the current challenges. Currently, the government is still implementing different solutions to mitigate the nitrogen crisis, these are further explained in the following section. Also, the key findings of the agricultural timeline will be further elaborated in the discussion.

5. Current and future solutions

To reduce the nitrogen depositions, deterioration of water quality, and the loss of biodiversity, various measures and subsidies have been proposed to mitigate nitrogen emissions over the past 70 years as explained in chapter 4. The following question will be addressed in this chapter; what viable pathways remain for farmers within Dutch agriculture to reduce nitrogen emissions, considering the various measures and subsidies proposed over the past 70 years? Note that the focus is on the perspective of Dutch agricultural entrepreneurs, based on proposals and plans of the central government and governmental bodies, the most apparent options, according to chapter 4, are described. According to the Dutch central government, a switch to circular agriculture, quitting or relocation of the agricultural business are the three main options for the agricultural sector to reduce nitrogen emissions, this is shown in figure 8.

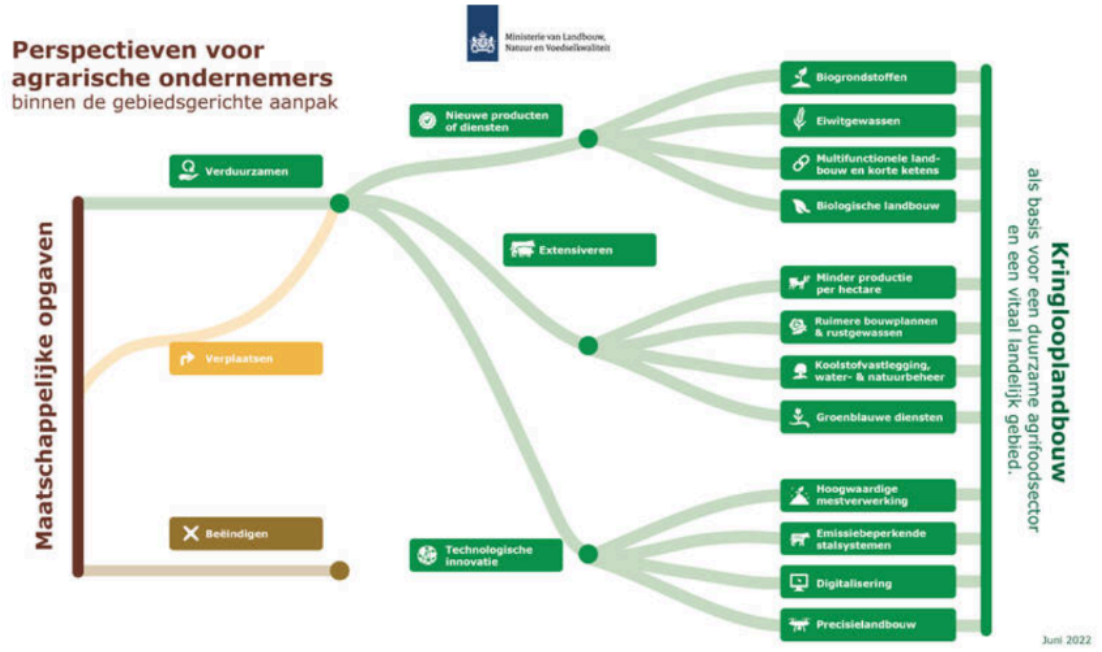

Figure 8: Perspective for agricultural entrepreneurs within the area-oriented approach according to the Ministry of Agriculture, Nature and Food Quality (n.d.)

5.1 Circular agriculture

Starting with the option to engage in sustainable farming practices, also referred to as circular agriculture. According to the Dutch Ministry of Agriculture, Nature and Food Quality (n.d.), circular

agriculture is supported by three different directions; extensification, innovations, and commutation of products or services, these options are often combined. First of all, circular agriculture is characterized by a closed cycle of raw materials. Nutrients in the soil are utilized for plant growth, providing food for animals that produce meat or milk, as well as manure. This manure is then reused to nourish the soil again (Wageningen University & Research, n.d.; ZLTO, n.d.). Another example is changing the diet of cows, resulting in a decrease of nitrogen emissions (Vogels et al., 2023)..

However, the combination of different sustainable agricultural practices is applied to comply with the nitrogen emission regulations. An example is given in figure 9, the completed circle shows 'waste recycling' this means optimizing the use of sources in general. For example; the wheat given to animals is of the same quality as what is used for human food.

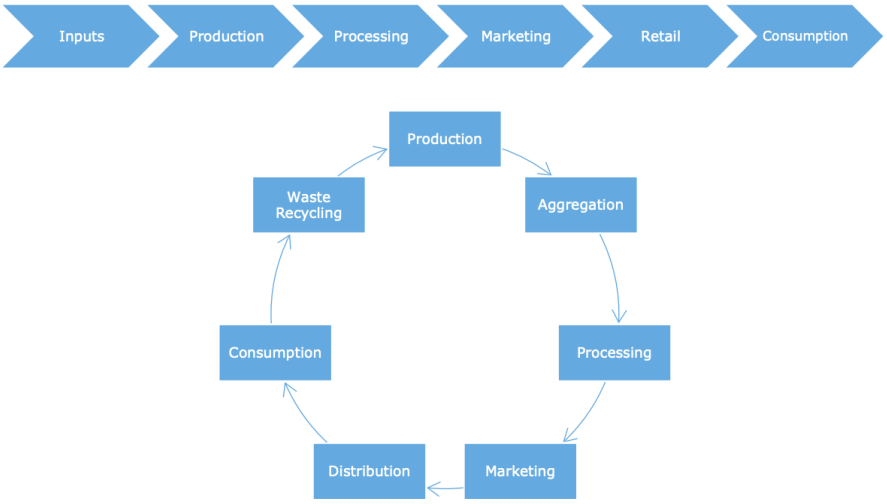

Figure 9: Linear and circular food system (Ruben et al., 2019)

The transition to sustainable practices necessitates the active participation of suppliers, customers and consumers otherwise the circle remains incomplete. Achieving this transition requires that the outcomes have to be economically advantageous for all involved parties. Therefore, it is essential to maintain a balance between socio-economic and environmental interests and outputs (Berkum & Dengerink, 2019).

5.1.1 Extensification, innovations and commutation of products or services

The extensification entails less production per hectare, halving the livestock, creating more space to build less, and carbon sequestration via water and nature management, also the input of diverse crop rotation to decrease the negative impact of nitrogen on the environment. Lastly, according to Erisman (2005), solutions include the improvement of nitrogen efficiencies. Moreover, embracing new technological innovations presents another direction for achieving sustainability within agriculture. Farmers can receive subsidies for this, for example, the investment in an improved manure processing installation resulting in less deposition of nitrogen due to the fast removal of manure (MinLNV, 2024).

5.2 Voluntary buyout scheme and farm relocation

Another option for farmers is to exit their agricultural business through a voluntary buyout scheme. This option is introduced for farmers who are not able to pay the bills, who live near Natura 2000 areas, or who do not have a successor. Farmers who will voluntarily stop farming can get subsidies for this, which is presented in the National termination scheme for livestock farming (LBV) (KvK, 2024). Another option, dependent upon the economic viability of the farmer, is the relocation of the agricultural business which are located too close to Natura 2000 areas.

5.3 European measures, funds and other subsidies

To make these options attractive, the government is supporting the farmers through subsidies enabling them to earn more while maintaining fewer livestock. Almost every option presented comes with available subsidies. For farmers who are willing to adopt sustainable practices, the government created a budget of 222.6 million over the next 2 years. The European Agricultural Guarantee Fund (EAGF), supports farmers in ensuring secure, healthy, and affordable food. Projects like ‘Cows and Opportunities’, and ‘Farming with a Future’, guide and assess the effectiveness of different measures for farmers (Erisman et al., 2005).

EU countries must commit to a minimum basic payment for farmers (EAGF, 2023). The Agri-Environmental and Climate Measures (AECM) promote environmental goals such as organic farming, and animal welfare through governmental contracts. However, these measures have been criticized due to a lack of local specificity. For Dutch farmers, an additional obstacle is that they must first be members of an agricultural organization to obtain a governmental contract with the AECM (Barghusen et al.,2022).

Concluding, the viable pathways remaining for farmers within Dutch agriculture to reduce nitrogen emissions, is an integrated solution including the increase of nitrogen use efficiency in agriculture, reducing waste in the food chain, promoting diets with less animal protein in developed countries, and a shift from fossil fuels to sustainable renewable energy sources such as solar and wind energy. All actors have to contribute to complete this circular agricultural system.

6. Discussion

The headline "How will we feed Earth's rising population? Ask the Dutch" from VOX, highlights the Dutch agricultural sector's reputation for its hyper-efficient food system (Torrella, 2023). The dutch efficiency comes with significant environmental costs, particularly concerning nitrogen emissions. Over time, farming has culminated in a complexity of policies and regulations, and lost its simplicity and aim of the provision of nutritious diets for humans and animals and the definition of applied ecology is hard to find. The nitrogen crisis exemplifies the intricate challenges within Dutch agriculture, balancing socio-economic needs and environmental sustainability. Despite continuous efforts of policies and regulations, these have until thus far failed to resolve the nitrogen crisis.

6.1 Key findings

The analysis of historical and regulatory developments over the past 70 years reveals a significant shift in priorities from economic growth to environmental management. In the search for the answer on the question of how the interest of governmental bodies and farmers change over time? It became clear that a notable shift in priorities, with nature and environmental concerns taking precedence over purely economic interests, occurred in 1987 (Karel, 2010). This shift is marked by policies such as the Dutch Manure and Fertilizer Act and the Zorgen voor Morgen report, reflecting the emphasis on environmental concerns driven by activist groups and scientific evidence (Karel, 2010).

Both the MINAS and the CAP, can be seen as attempts to create less polluting systems (Van Grinsven & Van Eerdt, 2020). The environmental damaging effects were acknowledged but the implementation of derogations, undermining environmental interests and the non-compliance with legislative guidelines. Derogations can be concluded as a significant contributor to the nitrogen crisis. By consistently surpassing the critical deposition values in Natura 2000 areas through derogations, the natural environment continues to deteriorate at an accelerated pace. Despite the dominance of agricultural production that began in 1950, which is still evident today, it has proven to be difficult to move away from this position (Karel, 2010).

Energy researcher, scientist, and publicist Remco de Boer (2018) argues that countries too often rely on reports about climate policy to feel reassured that "all is well". The brief existence of the Nitrogen approach program (PAS), from 2015 to 2019 exemplifies this issue; it was clear from the outset that these plans were inadequate. Nonetheless, it was ignored. The PAS represents a policy failure that was driven by a focus on production increases since the 1950s while postponing the actual nitrogen problem.

The Netherlands is a clear example of a country profiting from the cheap availability of reactive nitrogen through the Haber Bosch process (Erisman et al., 2005).

6.2 The necessity for change in agricultural policy

As highlighted in Section 2.4, changes in stakeholder interests have greatly influenced the nitrogen crisis. Agricultural policies have transitioned from prioritizing socio-economic interests to focusing on environmental concerns, driven by increased knowledge and input of environmental organizations. Remco de Boer (2018), argues that critical examination of climate policy is often met with resistance. However, Follet and Hatfield (2001), emphasize for policymakers and experts to collaboratively address both agricultural and environmental concerns. A coordinated approach is essential, as individual efforts are less effective without similar regulations in neighboring countries, emphasizing the need for leadership from Europe and the European Commission. This analysis underscores the need for systemic change at the policy level, in consumer behavior, and through international cooperation to effectively address the nitrogen crisis. Moreover, when critically examining the agricultural timeline, it almost appears necessary to transition back to the diverse landscapes, crop rotation, and extensive agriculture practices prevalent around the early 1950s.

6.3 Implications and validity

This research is highly relevant as the urgent need for change is addressed by the ongoing negative environmental impacts of the nitrogen crisis. Meaningful progress can only be made through comprehensive understanding and transparent dialogue. This paper provides valuable insights by analyzing historical and regulatory developments in Dutch agriculture over the past 70 years, and offers clarity and transparency in the complexity of the Dutch nitrogen crisis. Understanding the historical and policy context of this issue is crucial for developing effective solutions that address both environmental and socio-economic concerns. This study provides clarity and transparency, contributing to informed public debate and more nuanced policy-making, ultimately benefiting all facets of society impacted by the nitrogen crisis. This literature research primarily relies on a comprehensive review of historical and regulatory documents, scientific literature, and media sources. By using established and peer-reviewed sources such as the work of Erisman et al. (2005) and policy analysis reports, the research ensures a high degree of credibility and validity.

6.4 Limitations and further research

While the narrative literature review provides a broad understanding of the historical and policy context, it also has limitations. The reliance on available literature and media sources may introduce bias, as certain perspectives can be overrepresented or underrepresented. Furthermore, as mentioned in the

introduction, it is an emotionally heated topic, capturing this is relevant to create a comprehensive overview in this complexity. This could have been strengthened by using empirical data through interviews with farmers, environmental organizations, and governmental bodies. Due to time constraints, this was not feasible.

Lasly, while this study focuses on the broader picture, further research could be done on the long term effects of the evaluated policies. This can help identify which measures are effective in mitigating the nitrogen crisis and promoting sustainability in the agricultural sector.

7. Conclusion

To address the research question, “How did historical and regulatory developments in Dutch agriculture and stakeholder interests lead to the nitrogen crisis?” This paper analyzed the socio-economic, environmental, and agricultural actions and regulations that have contributed to the current nitrogen crisis in the Netherlands. Regardless of the continuous efforts of policy implementations, the interaction of derogations, farmer activist organizations, and the struggle to balance socio-economic needs with environmental sustainability have culminated in the nitrogen crisis.

Historically there has been a noticeable shift in regulatory developments. The emphasis shifted from socio-economic interests to environmental interests. Most of the policies failed to balance these priorities. This failure may arise from the complexity of the issue, conflicting interests among stakeholders, and insufficient implementation of proposed solutions and regulations. But above all due to the derogations and farmer protests, the environmental problem was postponed and the nitrogen crisis emerged. As stated in the introduction, significantly reducing livestock by 90 percent may be a necessary first step towards protecting the environment. Ultimately, adopting a more sustainable way of agricultural practices is necessary to live in a healthy environment.

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