Business Model Recommendations for the Dutch Manure Processing Niche

Julian D. Both

Royalty free picture by Matthias Zomer from Pexels

TU Delft

Analyzing the current manure processing and recycling niche in the Netherlands to see how business models can help innovators in the niche succeed

by

Julian D. Both

to obtain the degree of Master of Science in Management of Technology

at the Delft University of Technology,

to be defended publicly on Thursday march 10^{th}, 2022 at 3:30 PM.

Student number:	4474139	
Project duration:	14/09/2021 – 10/03/2022	
Thesis committee:	Dr. U. Pesch,	Chair
	Dr.ir. J.N. Quist,	First supervisor
	Dr. U. Pesch,	Second supervisor

An electronic version of this thesis is available at `http://repository.tudelft.nl/`.

TU Delft

Executive Summary

Problem and objective:
Farming has been an essential part of society for thousands of years, but more recently climate change and environmental concerns began to arise, putting pressure on the agricultural industry since they are a significant contributor of nitrogen emissions, especially from livestock manure.

Fortunately, there are start-ups that try to overcome the nitrogen problem by developing, producing and implementing technology that processes, recycles and extracts nutrients from livestock manure. However, although government subsidies exist to entice these firms, many still fail since they do not have a good business model and cannot capture the market. This then leads to the main research question: *How is the manure processing and recycling niche in the Netherlands currently developing and how can business models help innovators in the niche succeed?*

Background research & methodology:
In order to answer the research question, a literature review on analytical frameworks was made, from which a framework was developed using the Multi-Level Perspective (MLP), Strategic Niche Management (SNM) and business models. This framework is then used to qualitatively answer the research question using desk research and semi-structured interviews. As part of the desk research, a list was made with over 100 firms in the Dutch manure processing industry, separated into roughly what type of manure they process and how they process it. This list formed the basis to eventually select 8 interview participants from, who were seemingly successful firms spread out roughly across the different types of firms.

Results:
Answering and discussing the results for the main research question is split up into two parts. For the first part of how the niche is currently developing, it has been developing relatively slowly for the last 30 years with more rapid developments mostly occurring in the last 10 years as regulations have been updated and the 2019 nitrogen crisis put pressure on the agricultural industry to reduce emissions. On the one hand, this is putting some people off from entering the industry out of fear of losing a huge investment as the market is unstable and uncertain, and since a lot of farmers just want to farm compliantly without any issues, but on the other hand, it is also attracting others (namely innovators) to an industry with a lot of potential and a lot investment opportunities from the government, which will likely have some big changes occurring in the near future. No-one can quite say with certainty where the industry will be heading in the future, but nonetheless manure processing is looking like a viable option to reduce nitrogen emissions while keeping the farmers and the economy in business.

For the second part of the main research question, business models can certainly help innovators in the niche succeed. By looking at current successful players, one can draw conclusions and insights to use for their own firm. In total 5 main business models were identified over 2 main classifications: manure processors, which include large one-owner installations, large cooperations, and small one-farm only installations, and equipment producers, which include broad producers and narrow producers. To clarify, the key differentiation between broad and narrow producers is

that the former focuses more on the system as a whole whereas the latter focuses on perfecting one part of the system. Of the 5 total identified business models, there was no one clear 'best' business model, but small one-farm only installations are less likely to be successful and there were definitely commonalities between successful firms that a new entrant can copy. These include that most firms focused on a good quality system/product/service rather than outright cheap prices, that active publicity was not required for this industry, and that there was a lot of collaboration with partners. To further elaborate and answer the second part of the research question, a new alternative framework showing the link between MLP, SNM and business models was also proposed, which shows that who is part of a firm's network has a big influence on forming their business model, putting an emphasis on making sure you get good, reliable people in your network. Furthermore, an updated business model canvas was also presented for the manure processing niche, and several barriers and opportunities were identified for the industry.

Conclusion and recommendations:
In the end, a current analysis of the industry and business models was made, with some good practical contribution. The results were generally logical and clear, but it was not without its flaws. These mainly stem from the fact that this is the first paper to analyse business models for the manure processing niche, and due it being exploratory and broad in nature it means that sometimes the 'why' was not always fully justified. There were also relatively few interviews, which further limits how certain some of the findings are, but fortunately bias should not be significantly present.

As one of the outcomes, analysing the firms lead to quite a few recommendations for newly starting firms in the industry. The main ones being that newly starting firms should focus on a medium-large size installation capable of processing manure in a 15-20 km radius, offering a good quality product and/or service that works well, even if it may not be the newest, cheapest or most innovative method, and they should share their knowledge, collaborate and learn from each other.

However, some potential areas for further research were also proposed, including investigating other types of firms in the industry, the lesser successful firms to see what not to do, markets outside the Netherlands, and perhaps most importantly, also interviewing government personnel due to there being a fairly evident conflict between them and the agricultural industry. In any case, the manure processing niche is still looking like promising solution to the nitrogen problem, but only time will tell where the industry will head in the future.

Acknowledgements

I would like to thank everyone who has helped me throughout this project and I would like to express my sincere gratitude for their contributions. This project was no easy task, requiring a great deal of dedication, and it would not have been possible without their assistance, support, and supervision.

To start off with, I would like to thank Jaco Quist for supervising me and guiding me throughout this project, for taking the time to share your insights and expertise, and also for inviting me to your thesis circle meetings where I learned a lot. I would also like to thank Udo Pesch for inspiring me back in 2019 when I first followed your classes on Technology Dynamics and for challenging me to improve myself and this project, especially during our discussions.

I would also like to thank Adriaan Lieftinck and Edward Sibeijn for providing me with their experience and expertise about the industry and for guiding me in the right direction during this project to help me make it as good as possible.

Furthermore, I would like to thank all the participants I have interviewed for sharing their insights and experiences and for helping me discover more about the industry than I ever imagined. This project would not have been possible without all of you.

Last, but certainly not least, I would like to thank my friends and family for providing me with their support all throughout both my theses and helping me wherever possible, especially my brother Daniël Both and my dear friend Amir Sadjadi.

Contents

List of Figures

List of Tables

List of Abbreviations

BMC	Business Model Canvas
BPMED	Bi-Polar Membrane Electro-Dialysis
CAPEX	CAPital EXpenditures
CCS	Carbon Capture and Storage
CSR	Corporate Social Responsibility
DAF	Dissolved Air Flotation
EU ETS	European Union Emissions Trading System
HREC	Human Research Ethics Committee
KvK	Kamer van Koophandel (Chamber of Commerce)
MLP	Multi-Level Perspective
NCM	Nederlands Centrum Mestverwaarding
OPEX	Operating Expenditures
PAS	Programma Aanpak Stikstof (Nitrogen Approach Program)
PV	Photo-Voltaic
R&D	Research and Development
RENURE	REcovered Nitrogen from manURE
RO	Reverse Osmosis
ROI	Return On Investment
RQ	Research Question
RvS	Raad van State (Council of State)
SNM	Strategic Niche Management
TCO	Total Cost of Ownership
US	United States
WWF	World Wide Fund

1 Introduction

1.1 Background and problem statement: the nitrogen crisis and manure

For thousands of years farming has been an essential part of many societies and it is an essential part of modern life. More so, in the last 100 years the global population has risen substantially and rapidly, leading to a greater need for produce. Fertilizers are now used more often and animals and meat is consumed more than ever before, caused by a growing middle and upper class.

More recently, climate change and environmental concerns began to arise and it cannot be ignored that agriculture accounts for approximately 10-15% of all gas emissions caused by humans (van der Wal, 2018), which is also supported by figure 1.1 based on data from the US (Environmental Protection Agency, 2019). Moreover, a lot of the agricultural emissions are in the form of ammonia (NH_3) and nitrous oxides (NO_x), which harms the surrounding environment, can disrupt the ecosystem, contaminates rivers and can even cause health problems.

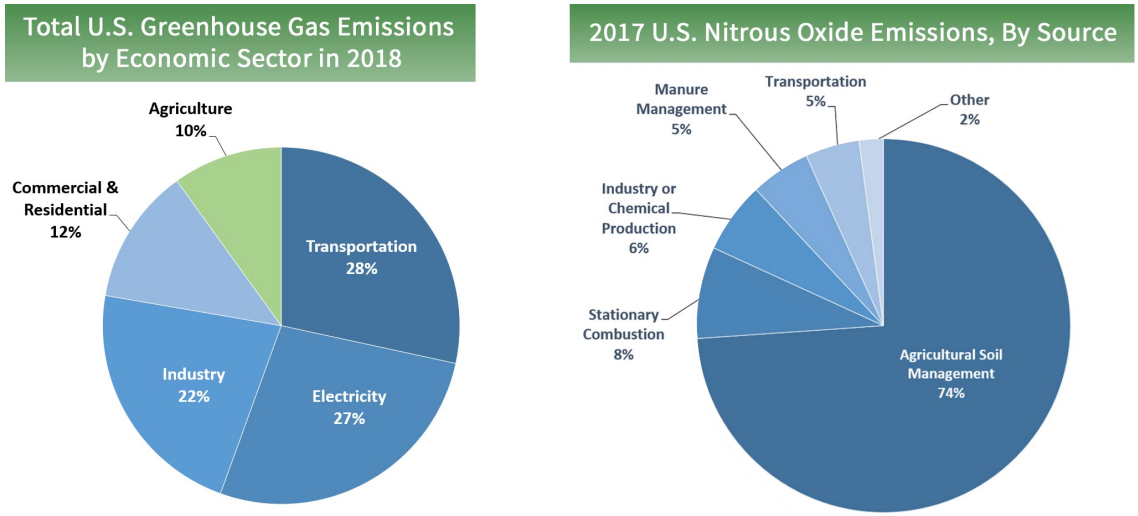

Figure 1.1: Agricultural gas emissions in the US (Environmental Protection Agency, 2019)

All this would not be that much of a problem if the emissions are widely spread out over a large area, limiting the environmental, ecosystem and health impact. However, that is not the case in the Netherlands. The Netherlands is the second largest exporter of produce in the World, just after the US, a country with approximately 20 times the population and 200 times the surface area, so it is no surprise that there is a large amount of concentrated farming and livestock in the Netherlands (Catal & Tekinerdogan, 2019).

However, all this farming produces a huge amount of nitrogen emissions and deposition, especially from livestock manure, and this ultimately created the 2019 nitrogen crisis ("stikstofcrisis") where about 18,000 infrastructure and construction projects were halted near Natura 2000 areas because of

high nitrogen deposits above legal limits (NOS, 2019b). In fact, it was discovered that 46% of these nitrogen deposits came from the agricultural industry, which is the largest source by a significant margin (Rijksoverheid RIVM, 2019). Data from the European Union also showed this trend in the past with high manure usage (as fertilizer) and high nitrogen deposits in the Netherlands as seen in figure 1.2.

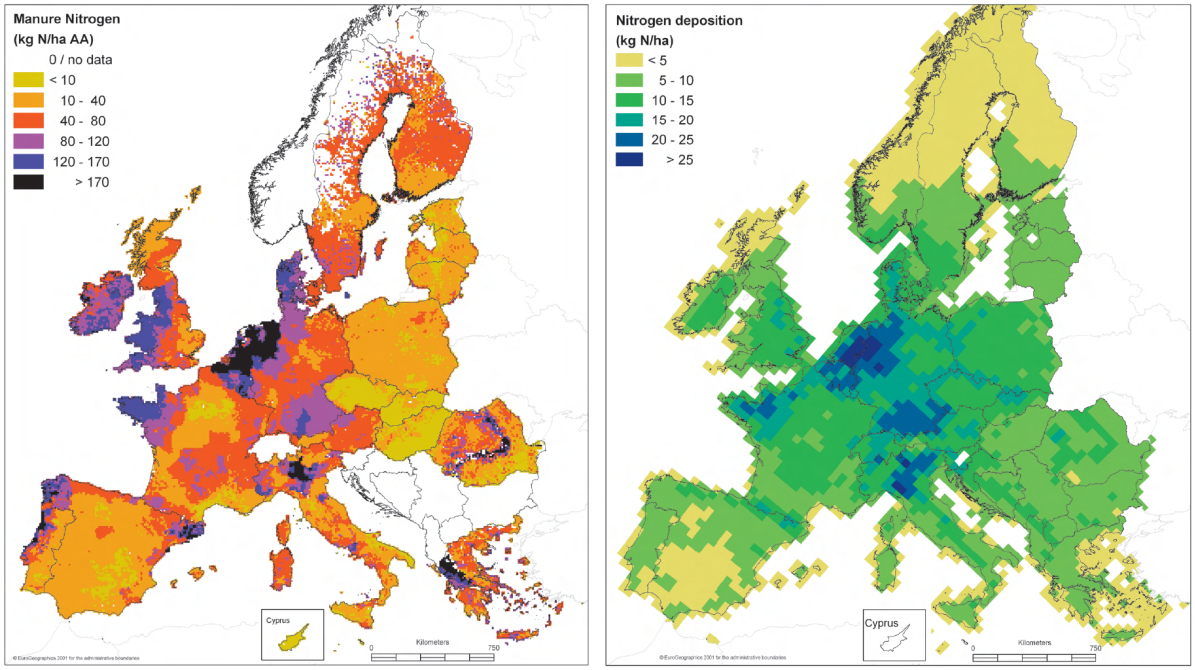

Figure 1.2: 2006 concentration map of applied manure fertilizer (left) & nitrogen deposits (right) (Bouraoui et al., 2007). Please note the wind commonly coming from a westerly direction slightly shifting the location of nitrogen depositions.

On top of this, there has also been international pressure by organizations like the World Wide Fund (WWF) and Greenpeace urging the Netherlands to reduce their nitrogen emissions, as well as plans to take legal action if emissions are not lowered quickly (NOS, 2021).

Several solutions to the nitrogen problem have been proposed in the Netherlands. These range closing airports such as Schiphol and halving the number of cars on the road (Hermus, 2021) to halving the amount of livestock allowed on a farm (Winterman, 2019) or even using fewer fertilizers and protein-rich feed for livestock. However, practically all of these proposed solutions carry negative side-effects on society. Using fewer fertilizers and less protein-rich feed does reduce emissions, but it also significantly reduces the yield of meat and crops, just like halving the number of livestock on a farm. This would not only reduce employment, it will severely harm the Dutch export, where in 2017 agriculture accounted for €92 billion out of the €101 billion of Dutch exports (Ministry of Agriculture, 2018).

1.2 Objective: manure processing and recycling niche

Fortunately, there are start-ups that try to overcome the nitrogen problem by developing, producing and implementing technology that processes, recycles and extracts nutrients from (livestock) manure. By removing the nitrogen from manure, it prevents nitrogen emissions from occurring from manure in the first place without the negative (side-)effects on society. This in turn allows for a more sustainable (or in some cases even circular) usage of manure rather than have nitrogen emissions leave the cycle and into the environment where they are harmful.

Such new innovations are on the rise and enticed by government subsidies, however, many of these innovations and firms will eventually still fail, as they do not have a good business model that fits with the socio-technical regime and environment and thus are not able to capture the market and grow. If it is somehow possible to help these start-ups (by helping them have the best business model that fits in their environment and conditions), it will not only help more start-ups flourish and grow, it will help the Netherlands work towards a more sustainable and greener future with fewer nitrogen emissions.

Thus, the main objective of this paper is to make (business model) recommendations for new manure processing and recycling start-ups to give them the best chance to succeed. In order to achieve this, first the current niche and its environment, including the business models of current players, will be analysed to gain a good insight into the niche and its development. This will then be used as an input to see what works well for firms in the niche and what factors influence the decision of business models, which in turn can be used to make recommendations.

1.3 Research questions

As evident from the main objective, the main research question is as followed:

> *How is the manure processing and recycling niche in the Netherlands currently developing and how can business models help innovators in the niche succeed?*

In order to answer the main research question, several sub-questions are proposed, which can be answered chronologically in subsequent chapters. Please note that these sub-questions are already distinguished and formed according to literature theories, which will be discussed in the following chapters. For further elaboration on the research (sub)questions, please refer to the start of the research methodology chapter.

1. What is the current socio-technical regime and landscape and how does it affect the niche?
2. How do current niche firms capture the benefits or tackle the problems of the regime and landscape?
3. What sort of business models do firms in the niche currently use?
4. What trends and patterns arise from the niche and their business models and what sort of (business model) recommendations can be made to newly starting firms in the niche?

1.4 Research scope

The focus of this paper is on making business model recommendations to the manure processing and recycling niche. Although the main goal of reducing nitrogen emissions can have a focus on many different sources (e.g. transport, construction and industry), for many of these sources the solution (or at least the path to the solution) is clear, such as replacing fossil fuels with renewable energy, even if the solution itself may still be difficult to obtain. However, for the agricultural sector the situation is a bit more controversial as not everyone agrees to what the solution should be and there is currently a lot of debate on the high quantities of livestock in the Netherlands and what to do with their emissions, like manure (Winterman, 2019). This makes livestock a very relevant focus and within livestock, the manure usage is an area where there is still a lot of improvement left to be made for emissions.

Similarly, the location focus of this paper is the Netherlands, since being one of the largest produce producers and exporters in the world with pressure from multiple parties, it will have a reasonably high quantity of start-ups in this niche trying to solve the nitrogen problem of manure, making it one of the best locations to focus on for this analysis. Although the focus is on the Netherlands, it is certainly also possible to apply the outcome of this research to the agricultural industries of other countries, thus having a potentially global impact. However, that would be a future point of research.

The time-span will only be the present time with current players. Although it is possible to consider the last approximately 30 years since the first introduction of laws limiting the quantity of manure allowed on farms in 1992 (European Union, 1992), the laws regarding manure have not actually changed significantly since then and neither have there been many significant new factors affecting development. Therefore it is more useful to consider the present time where all views, actors and business models are up-to-date and no comparisons will be made comparing a factor that may have had an effect 20 years ago to something that would not have an effect today.

1.5 Practical relevance and relevance to MOT course

As mentioned previously, this thesis is on a very relevant topic. Nitrogen emissions are a huge problem that society faces and by investigating the niche itself and the business models that the niche uses, it will be possible to make recommendations to new players in the niche so that more innovations can succeed. Without the right business models, potentially radical innovations that could severely help out the environment may never come to fruition if the business fails. Similarly, the more niche start-ups have the right business models and have the right fit with their environment and conditions, the higher the chance that one of the potentially 'game-changing' innovations breaks through to change agriculture for the better. In that sense the practical relevance is also the managerial relevance as a manager of a niche firm should be able to use the outcome of this paper to come up with a more robust business model or to at least check if they are on the right track.

This research is also very relevant to the Management of Technology (MOT) programme. Taken directly from the MOT programme objective, "the programme addresses challenging questions most companies face such as:

- What technologies do we need and when?
- Do we procure the technology we need with our own research capabilities, in collaboration with outside parties, or by acquiring it or licensing it from others?
- How can we use the abundant technological opportunities to affect our mission, objectives and strategies?" (TU Delft, 2021)

Investigating the factors that affect the choices of the niche and investigating the business models that niches themselves use is directly related to these points and will help with the challenges that the niche companies face, not to mention that technology is a central focus point for manure processing and recycling innovations. Thus, this research is certainly relevant to the MOT programme.

1.6 Report structure

Chapter 1 focuses on the introduction, the objective, the research scope and the relevance of this paper. Next, chapter 2 goes into the background information on theories, as well as how and why these theories are used. Chapter 2 also already includes a literature review on the firms in the niche, including sorting by the processes and products produced. In chapter 3 the research questions and methodology will be explained, and an elaboration will be given on how the research sub-questions will be answered. Chapter 3 also already includes the grouping of firms in the niche as it will form the basis for interview participant selection for the following sections.

Afterwards, in chapter 4 the general outside factors (the socio-technical regime and landscape factors) affecting the niche will be investigated. Then in chapter 5 the factors from within the niche itself will be investigated via Strategic Niche Management (SNM) to see how firms in the niche try to capture value/benefits. Next, chapter 6 will expand on this by investigating what business models these firms in the niche use to aid in capturing value. Subsequently, after all these points have been considered, chapter 7 will analyse the trends and patterns in order to make (business model) recommendations for the niche firms.

Finally, chapter 8 will discuss the outcome of the findings, the limitations and academic contribution, while chapter 9 summarises the paper by reiterating the answers to the research questions from the prior chapters and makes recommendations for future research. An overview of the report structure can be found in figure 1.3.

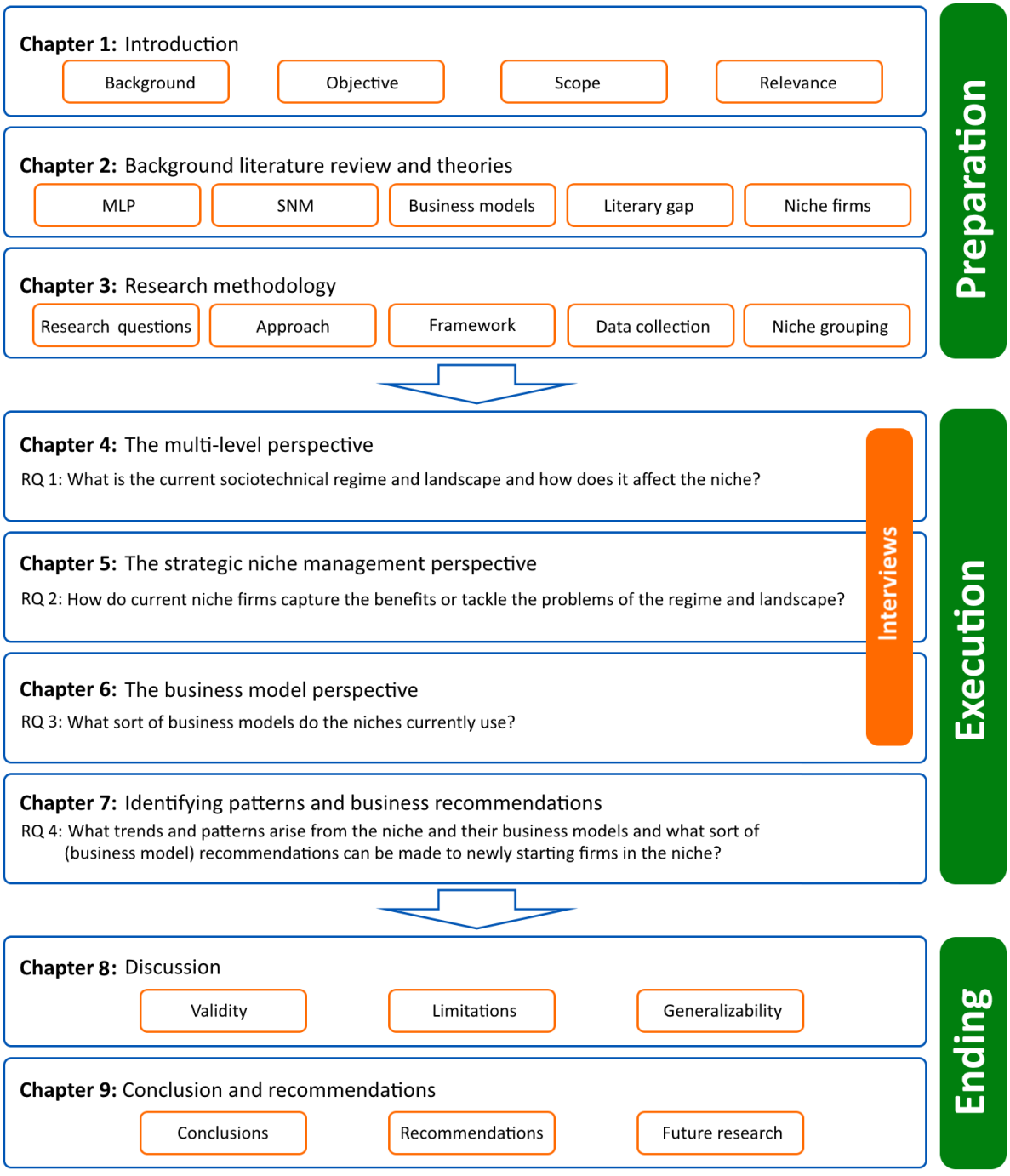

Figure 1.3: Overview of the report structure

2 Literature Review & Background

This chapter will discuss the theoretical theories and frameworks that form the foundation of this analysis. Since the main objective is to try to increase the adoption of the niche by helping these firms out, the main objective can be considered as supporting some form of transition from older to newer technology and as such frameworks that focus on transition are needed. Thus, the Multi-Level Perspective (MLP), Strategic Niche Management (SNM) and business model frameworks will be explored in detail in this chapter. Additionally, where possible, if variations on these frameworks are found with a particular focus or link with sustainability or business model aspects, they will be considered as well as it can aid in the analysis later on in the paper. Afterwards, background research specific to manure, including identifying the current players in the niche will be made. Finally, at the end of this chapter the knowledge gap in literature will be identified, which is also the basis for the academic relevance.

2.1 Multi-level perspective (MLP)

One of the earlier and more popular frameworks on transition that is still used today is the Multi-Level Perspective, first developed by Frank Geels in 2002 (Geels, 2002). Geels brought together insights from technological studies and evolutionary economics to come up with a framework describing how technological change comes about. In essence, a socio-technical transition (the 'change') will happen when the dynamic interaction between 3 levels are reinforced, namely the micro level (the niche), the meso-level (the regime) and the macro level (the landscape) (Geels, 2004). The framework explains that even though a technology may be suitable to be adopted, the outside factors need to support adoption or else it will not occur, meaning that for a transition to occur, the innovation must co-evolve with markets and the preferences of society (Geels, 2012). Hereby innovations in the niche start building momentum through experimentation and networking (thus improving performance), which together with landscape developments puts pressure on the current (incumbent) regime (Geels, 2012). Loorbach, Frantzeskaki, and Avelino (2017) even suggest that transition is caused by 5 core concepts: nonlinearity, multi-level dynamics, coevolution, emergence, variation & selection. An overview of the latest up-to-date multi-level perspective, including the 3 levels (landscape, regime, and niche) can be seen in figure 2.1.

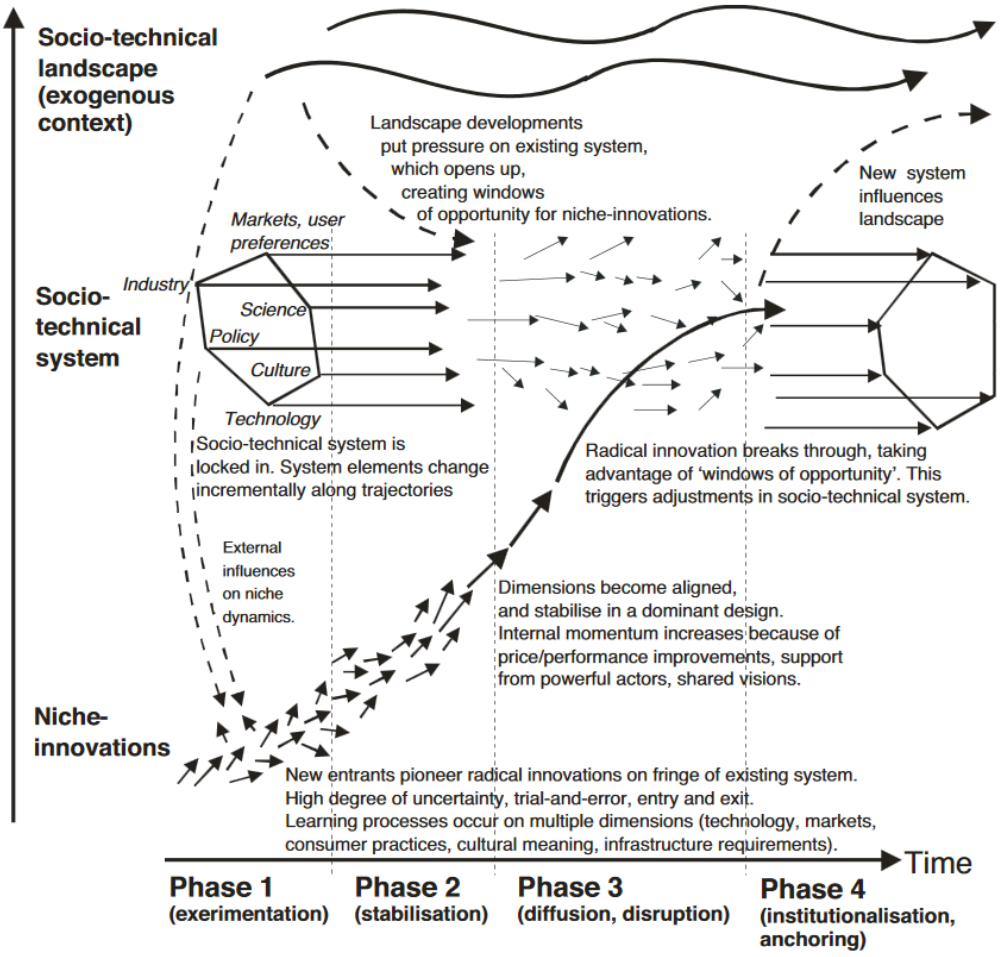

Figure 2.1: The latest 'up-to-date dynamic Multi-Level Perspective (Geels, 2019)

In the MLP a lot of emphasis is put on the regime-level, being the central 'middle' level of the framework and consisting of originally 7 elements: technology, markets, sectoral policy, techno-scientific knowledge, industrial networks, culture and infrastructure (Geels, 2002). However, the regime can alternatively be divided into 3 connected dimensions: the social network of actors, the technology fit and the regime rules that guide actions (Verbong & Geels, 2007). Geels (2004) also notes that the regime rules can be further split into 3 parts: regulative (formal laws, sanctions), normative (values, duty, code of conduct), and cognitive (priorities, beliefs).

The interaction between these dimensions is important as it can help or hinder the adoption of the niche through path dependencies and lock-in (Loorbach et al., 2017). When lock-in occurs, even if it may seem like the niche and landscape would allow for a transition and alteration of the regime, there can be no guarantee that the innovation will be adopted, because the existing regime resists change and has reinforced stability through lock-in mechanism (Geels, 2012). Furthermore, lock-in mechanisms can occur in the regime in the form of techno-economic lock-in (sunk investment costs

in infrastructure), social and cognitive lock-in (consumer preferences and lifestyles that are unlikely to be changed) and institutional and political lock-in (existing regulations and policy networks) (Geels, 2012, 2019). Furthermore, incumbent actors (firms) that have a stake or involvement in the regime may try to prevent change from occurring and stabilize the current regime, preventing niche transition. This can be done through confrontational strategies, framing strategies and lobbying, where incumbent actors may have easier access and greater influence on the decisions of policy makers (Geels, 2019).

However, if the interaction between the 3 dimensions is reinforced, it can also aid in transition. Geels, Sovacool, Schwanen, and Sorrell (2017) further analysed the co-evolutionary interactions between technologies and societal groups and identified 3 mutually reinforcing processes that help accelerate transitions: i) an increase in momentum of niche innovations (e.g. multiple innovations linking together to improve functionality and to reconfigure systems), ii) the strengthening of exogenous pressures (e.g. via governmental policies) and iii) the weakening of existing systems (e.g. phasing out existing technologies and systems). When these 3 factors are aligned, a window of opportunity can occur where the niche can trigger a change in the existing regime (Geels et al., 2017). This concept can be seen more clearly in figure 2.2.

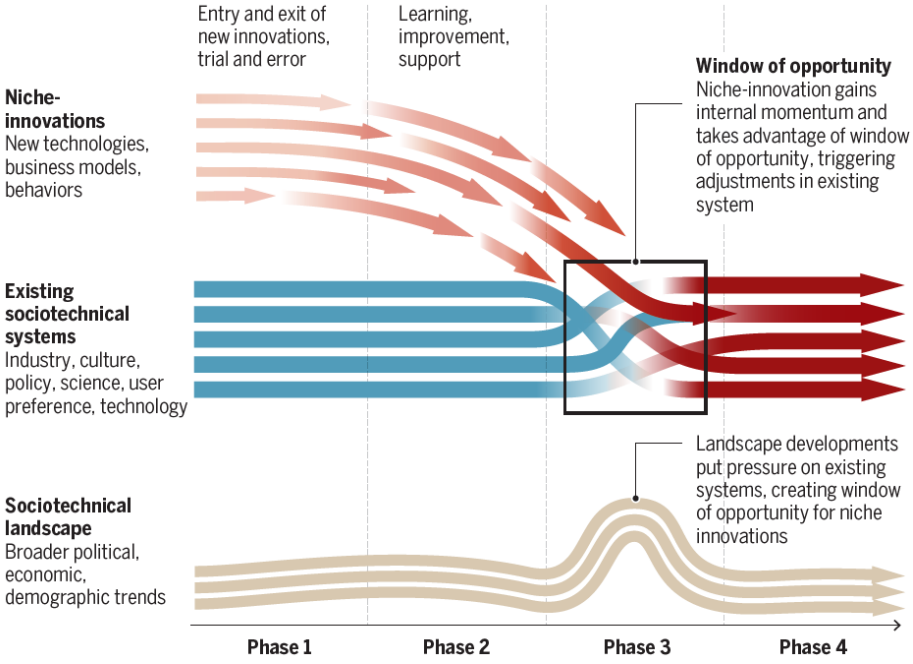

Figure 2.2: The window of opportunity in the MLP (Geels et al., 2017)

Furthermore, what transition path the niche takes depends not only on the nature of the multi-level interaction, but also the timing. This can already be seen in some of the newer figures, as the MLP is split into four phases, as seen in figure 2.1 and 2.2. Moreover, it is suggested that the timing and nature of multi-level interaction can lead to four different transition pathways: substitution, transformation, reconfiguration and de/re-alignment (Geels et al., 2016).

However, the MLP is not without its drawbacks and criticism. Geels (2011) responded to such criticism in 2011, which are related to 7 points: (1) methodology, (2) regime operationalization, (3) socio-technical landscape as residual category, (4) explanatory style and epistemology, (5) lack of agency, (6) bias towards bottom-up change models, and (7) hierarchical levels versus flat ontologies. The paper concluded that due to transitions being a multi-faceted and complex topic that there is likely to be disagreement and that because of that there is still room for improvement. Nonetheless, he concluded that the MLP is still well-suited to addressing the special characteristics of transitions (Geels, 2011).

Similarly, in 2019 Geels responded to criticism again to improve the framework, especially from the direction of sustainability transformation (Geels, 2019). Some limitations have remained unsolved, such as that there is limited attention given to socio-sustainability aspects (e.g. poverty, inequality) and the socio-ecological aspects (e.g. taxes, labour market). However, Geels also elaborated on 7 topics. These topics are (1), policy analysis (2) framing struggles and cultural discourse, (3) destabilization and decline, (4) multiple transition pathways, (5) reorientation and incumbent firm resistance, (6) grassroots innovation, and (7) politics and power. This literature review will not go into detail into these topics, but some are certainly relevant and can be used later on. For example, for the Policy Analysis topic, it is mentioned that policy makers should facilitate discussions, learning processes and interactions and Geels mentions that the Strategic Niche Management (SNM) approach aims for such a transition-oriented policy, not just via R&D funding, but with aiding in real-life projects and experimentation, and via orchestrating coalitions that include new entrants to the niche (Geels, 2019). Since policy is an important aspect for the manure processing and recycling niche, it would be useful to keep SNM into consideration and coincidentally, SNM is the second framework to be reviewed next.

2.2 Strategic niche management (SNM)

To be able to fully analyse the niche, the MLP alone is not enough as it has a large focus on the regime and not enough focus on the niche (Geels, 2011). Having a good focus on the niche is important, as the niche analysis is used as a tool to answer the main objective, since it will likely give new insights to make (business model) recommendations. Thus adding a framework dedicated to niches would aid in the analysis. For this, Strategic Niche Management (SNM) has been chosen as it is commonly and easily combined with the MLP for a stronger analysis (Schot & Geels, 2008).

The concept of SNM was originally introduced in the 1990s as a policy and research tool for managing and analysing technological innovation and to achieve sustainable development at the niche-level (Kemp, Schot, & Hoogma, 1998). Additionally, SNM states that the niche analysis can be seen from both the technical and social side and as such SNM is a tool for analysing socio-technical transition (Hoogma, Kemp, Schot, & Truffer, 2002; Raven, 2005).

However, as mentioned during the MLP literature review, lock-in mechanisms exist in the regime, resisting change and hindering transition, and niches may even encounter further obstacles and uncertainty (Geels, 2012). Because of this, it is necessary to add some form of protective barrier to aid the transition of these niches (Smith & Raven, 2012). With this, the concept of a protected space is created within SNM where technological niches can be developed and nurtured to aid in

the adoption of radical innovations (Kamp & Vanheule, 2015). This protected space consists of 3 main elements; shielding, nurturing, and empowering, which will be explained in more detail next (Smith & Raven, 2012).

2.2.1 Niche shielding

The first element of the protected space is shielding, which is defined as the process of guarding emerging innovations against selection pressures of the regime (Smith & Raven, 2012). Several papers have noted that niches have difficulty overcoming these selection pressures, which are split up into the existing industry, policy, technology, culture, science and markets and user preferences, as seen in figure 2.2 (Geels, 2019). Niche shielding can also be split up into two types: passive shielding and active shielding, as proposed by Smith and Raven (2012).

Passive shielding is where the niche develops in such a way that the selection pressures are less intense than the otherwise 'normal' regime. This is typically via a different geographic location where the incumbent actors are of a smaller size and fewer lock-in mechanisms exist, such as in an emerging market for example (Smith & Raven, 2012). In a way, passive shielding allows the niche innovators to experiment and be adopted by a smaller quantity of users until it is economically feasible enough to be adopted by a mainstream market where regime pressures do exist.

Meanwhile, active shielding aims to prevent the selection pressures from reaching the niche that would otherwise hinder it, such as interventions from actors in the regime (e.g. a larger incumbent firm out-pricing the niche innovation). This can be done via various ways and Smith and Raven (2012) lists examples to combat each of the socio-technical regime pillars. These will not all be listed, but just to name a few; policies such as incentives, subsidies, tariffs, regulations and taxes can be used, but also via changing preferences, such as information campaigns, market segmentation and portfolio standards/quotas (Smith & Raven, 2012).

2.2.2 Niche nurturing

The following step after the niche has been shielded in the protective space is to nurture it. Nurturing occurs through three main reinforcing processes and every time the niche is nurtured via one of these processes, it creates a reinforcing mechanism between the processes. The three processes are as followed and will be discussed in more detail next: the voicing and shaping of expectations, the formation of networks, and the iterative learning processes (Raven, 2005).

i) The voicing and shaping of expectations:
One of the key deciding factors on if a firm will invest in researching a technology is the expectations of the new technology's future. As such, it is this voicing of expectations that attracts new actors and resources and gives direction to the development of the technology and if these expectations are clear and coherent, then the niche will attract and develop more (Kamp & Vanheule, 2015). Similarly, actors that have different expectations will not contribute to a shared knowledge base and the different experimental findings may not reinforce each other, which can ultimately even lead to different technological trajectories (Raven, 2005).

ii) The formation of networks:
Throughout the formation of the niche, a network of actors is being made that are dynamically linked and interacting with each other. These actors can be anyone involved in the development of the niche like researchers, suppliers, producers, customers and even regulatory bodies and each actor can have different expectations, values, motivations and strategies for their involvement. Because all these actors have different characteristics, it is important to have a good alignment between actors, as a balanced and compatible network can be a deciding factor on if the innovation will be successful or not (Raven, 2005). To give an example, a large incumbent firm may provide resources to a small niche start-up, but in such a network the expectations of the large incumbent firm may be to maximize profits, whereas the niche start-up may want to actually improve the world/society. This misalignment of expectations may then hinder the success of the niche development. Raven also suggests that a stronger alignment may be made between actors through formal cooperation (Raven, 2005).

Another factor that aids niche development is the network composition. It is beneficial to have a network with a wide variety of interests and roles, especially if the actors complement each other (Kamp & Vanheule, 2015). For example, it was noted that a niche will likely want a network composed of actors with no strong ties with the incumbent regime as they are more likely to promote radical innovation typical in the niche. However, studies have also shown that incumbent regime actors might actually support niches, sometimes through supplying resources (Diaz, Darnhofer, Darrot, & Beuret, 2013). Moreover, Kamp & Vanheule also pointed out that sub-networks may also exist, which consists of firms and researchers in the larger niche with similar roles (Kamp & Vanheule, 2015). These sub-networks, just like 'normal' networks, may change in size and composition over time (Kemp et al., 1998).

iii) The iterative learning processes:
Development through learning occurs through repeated experimentation, where the technology is slowly improved and more is learned about the societal possibilities and public acceptability, which aids in improving the socio-technical fit (Raven, 2005). Moreover, there are 5 aspects of the learning process as defined by Hoogma et al. (2002): technical development and infrastructure, industrial development and production, development of user context, societal and environmental impact, and government regulations and policies. Furthermore, Kamp and Vanheule (2015) identified two more aspects of the learning process: resource potential, which is the degree to which actors have been learning about available resources, and business models, which is the degree to which actors have learned about business models to aid in their success. Moreover, as the learning process progresses and more is known about the niche's technology and social implications, it can lead to expectations evolving over time (Kemp et al., 1998). These evolving expectations can subsequently change the shaping and voicing of expectations and alter the formation of networks, which shows that the iterative process is not just limited to the learning processes, but to the entire concept of niche nurturing.

An overview of the three main reinforcing processes of nurturing can be found in table 2.1.

Table 2.1: Overview of the 3 niche nurturing processes (Kamp & Vanheule, 2015)

Niche process	Indicator	Analysis of
Expectations	Internal expectations	the quality, robustness and specification of expectations of the current actors in the niche
	External expectations	the awareness and confidence level of actors outside the niche
	Exogenous expectations	expectations originating from developments that are external to the niche expectations: landscape and regime factors, the development and/or rise of other niches
	Endogenous expectations	expectations originating from learning experiences and network composition within the niche
Network formation	Network composition	the desired network composition and network completeness
	Quality of the sub networks	the extent to which the involved actor groups contribute to niche development
	Network interactions	how and to which degree the network actors are interacting
	Network alignment	the degree to which actors' vision, expectations and strategies are in line with the niche development
Learning processes	Technical development and infrastructure	the learning about design specifications, complementary technology and the required infrastructure needed for technology dissemination
	Industrial development	the learning about the production and maintenance network needed to broaden technology dissemination
	Social and environmental impact	the learning about the technology's impact on safety, energy and the environment
	Development of the user context	the learning about the end-user characteristics, their requirements, their barriers for technology adoption and the meanings they attach to a new technology
	Government policy and regulatory framework	the learning about the institutional structures and legislation that are relevant for dissemination, and the incentives they can provide to encourage adoption
	Wind potential and analysis	the learning about the available wind resources
	Appropriate business models	the learning about business models that enable successful market penetration

2.2.3 Niche empowerment

After nurturing, the final step is empowerment. By this point the niche is more developed and backed up by various actors and activities and thus is ready to take on the different challenges of the socio-technical regime dimensions in a competitive manner (Smith & Raven, 2012). This means that the niche can finally move from the protected space and penetrate the regime, becoming a part of it. As mentioned before, regime developments and landscape pressures on the regime can offer a window of opportunity, which aids in this final step of penetration (Geels et al., 2017). However, Smith and Raven (2012) suggests that the niche itself can also put pressure on the regime through empowerment activities, making the innovation more competitive. These are split into two categories: fit and conform, and stretch and transform.

i) Fit and conform:
Here the niche becomes competitive without altering the regime's selection pressures. By doing so, the niche is limited to slow incremental improvements instead of quick, radical changes, since the innovation has to conform to the current regime. In that sense it can be considered that the niche is dis-empowered as it aligns with existing norms and structures rather than making (potentially beneficial) changes to the regime. However, this is not a bad thing per-se. If a niche can conform to the current regime and then landscape pressures occur on the regime (e.g. taxes for polluting systems when the niche is a 'greener' solution), the niches that were once just conforming can now take over the market as a new leader and redefine the regime (Smith & Raven, 2012).

ii) Stretch and transform:
Here the niche becomes competitive by altering the regime's selection environment, aiding the diffusion of niche innovations. In essence the "rules of the game" need to be changed for the niche to become competitive, which can occur through changing laws, regulations and incentives. However, in order to achieve this, coalitions and political formations are required to build a social

movement and induce a change (Smith & Raven, 2012). One argument in favour of the stretch and transform empowerment is that it likely has a more transformative effect on the regime since it allows and encourages more innovations to be developed (as they do not need to 'conform'). However, it was also noted that due to the significant changes this may bring to the regime that this form of empowerment is less likely to occur in practice, unless there is significant influence from society and political actors.

2.3 Business model frameworks

Another framework that will be used in this paper is that of business models. Making (business model) recommendations to new start-ups in the niche is the main objective of this paper, so having good knowledge on business models and their frameworks is important. Unlike the MLP and SNM, business model frameworks are not as 'set in stone' and so multiple business model frameworks may need to be considered. In fact, the term "business model" and "business strategy" was sometimes used interchangeably in the past and it basically meant something that the firm believed would give them a competitive advantage (Osterwalder, Pigneur, & Tucci, 2005). However, to clarify and define this, business models often times contain not only strategy, but also the ICT and business organization, which takes outside forces like the social environment, technological change and customer demand into consideration. Bidmon and Knab (2018) support this idea as technological innovation alone is not enough and non-technological factors like business models are required to cause a transition.

As such, the business model can be seen as a tool to express the firm's business logic by containing the value the company offers to its customers and the architecture on how it aims to create, deliver and market this value (Osterwalder et al., 2005). For this, 9 business model building blocks are proposed that together create value and sustainable revenue streams. The description of these 9 building blocks, which were slightly updated in 2010, can be found in table 2.2.

Table 2.2: The business model building blocks (adapted from Osterwalder and Pigneur (2010))

Building Block:	**Description:**	**Examples/factors/types:**
Customer Segments	The people, organizations or groups that the firm wants to reach and serve and can vary depending on behaviour and needs/wants	Mass market, niche market, diversified, segmented, multi-sided
Value Propositions	The products and/or services that create value for the customer segment, to satisfy customer needs	Newness, low cost, performance, customization, design, brand or status, accessibility, convenience
Channels	how the firm reaches out to the customer segment to deliver value (communication, distribution, and sales channels)	5 phases: awareness, evaluation, purchase, delivery, after sales
Customer Relationships	the type of relationships the firm establishes with its customer segments for acquisition, retention and boosting sales	Personal assistance, self-service, communities, co-creation, automated service
Revenue Streams	The cash a firm generates from successfully offering value to its customer segment, either as a one time or recurring transaction	Asset sale, usage fee, subscription-based, rent/ lease, licensing, brokerage, ads
Key Resources	the most important assets that are required to be able to deliver value	Physical, intellectual, human, financial
Key Activities	The things the firm does to make their business model work to deliver value	Production, problem solving, platform/networking
Key Partnerships	The network of partners and suppliers required outside of the firm to make the business model work. Done to achieve optimization (economies of scale), reduction of risk or to acquire resources	Strategic alliances, joint ventures, coopetition, buyer-supplier relationships
Cost Structure	The costs incurred from operating the business	Cost-driven, value-driven, fixed costs, variable cost, economies of scale, economies of scope

Moreover, it is possible to combine these building blocks into a visual representation to create the business model canvas: one of the first extensive frameworks/tools to identify a firm's business model (Osterwalder & Pigneur, 2010). A firm can fill this canvas in during (for example) a workshop to gain insights into their business model. The business model canvas can be seen in figure 2.3 and it is useful to note that the left half of the canvas focuses on efficiency, while the right half of the canvas focuses on value.

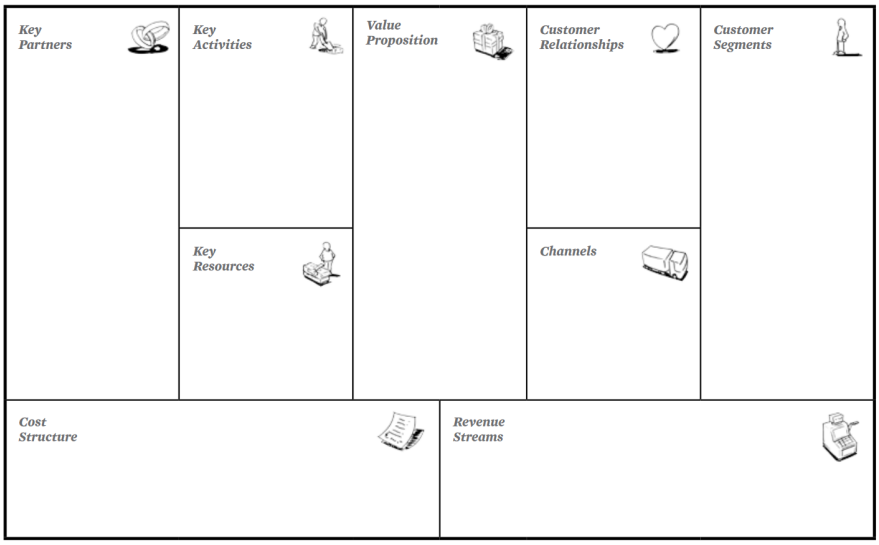

Figure 2.3: The business model canvas (Osterwalder & Pigneur, 2010)

Generally, the concept of the business model canvas and the 9 building blocks is relatively popular and widely cited, but this did not stop others from attempting to improve the model. One key drawback of the business model canvas that was pointed out by multiple papers is that it does not take any form of sustainability into consideration, as it is focused on providing a financially successful business model (Bidmon & Knab, 2018; Boons & Lüdeke-Freund, 2013; Lewandowski, 2016). This is a problem, as innovation in business models can be used to overcome the diffusion barriers of new clean technologies, thus allowing the adoption of sustainable innovations (Boons & Lüdeke-Freund, 2013). By including sustainability aspects, a stronger business model can therefore be made for sustainable innovations.

To contribute to sustainability in business models, Bidmon & Knab defined 3 roles of business models in societal transitions and made the link between these 3 sustainable business model roles and transition research (Bidmon & Knab, 2018). The 3 roles are 1) as part of the socio-technical regime, where current business models reinforce the stability and prevent transitions from occurring, 2) as an intermediate, where the business model aids in the breakthrough from niche to regime, or 3) as a non-technological niche innovation, where new business models drive transition via forming a new regime without the need to rely on technological innovation. By identifying these 3 roles, Bidmon and Knab (2018) emphasises the importance that to make a change, non-technological factors like business models should also be considered, since technological innovation alone is not enough.

However, the methods of linking or including sustainability have varied across literature. Boons and Lüdeke-Freund (2013) aimed to solve this via a framework consisting of only 4 generic elements of a business model (value proposition, supply chain, customer interface and financial model), but linked each of these elements to sustainability aspects.

Meanwhile, Lewandowski (2016) took a different approach and extended the framework of the business model canvas to include two additional indicators: i) the take-back system, which includes design of take-back management systems and includes customers and channels related to it, and ii) adoption factors, which are the various external factors and organization capabilities that support the transition towards circular business models. Lewandowski (2016) also proposed 6 circular business model types and linked them to the building blocks, of which an overview can be found in table 2.3.

Table 2.3: 6 circular business model types and their link to the building blocks (Lewandowski, 2016)

BM Components	**Regenerate**	**Share**	**Optimize**	**Loop**	**Virtualize**	**Exchange**
Partners		X		X		
Activities	X		X	X	X	
Resources	X		X	X	X	
Value proposition and Customer segments		X		X	X	
Customer relations						
Channels					X	
Cost structure	X		X	X		X
Revenue streams		X		X		
Potential to develop the BM framework						
Take-back system				X		
Adoption factors	X	X	X	X	X	X

Note: X indicates that the circular economy principles apply to the particular component of business model.

Similarly, Bocken et.al. also developed and proposed 8 sustainable archetypes, which are grouped by mechanism and solution, each essentially being its own form of business model (Bocken, Rana, & Short, 2014). The 8 archetypes including examples can be seen in figure 2.4. However, one important note is that each archetype is not explained using all 9 building blocks, but rather a simplified version consisting of just 3 building blocks: value proposition, value creation & delivery, and value capture.

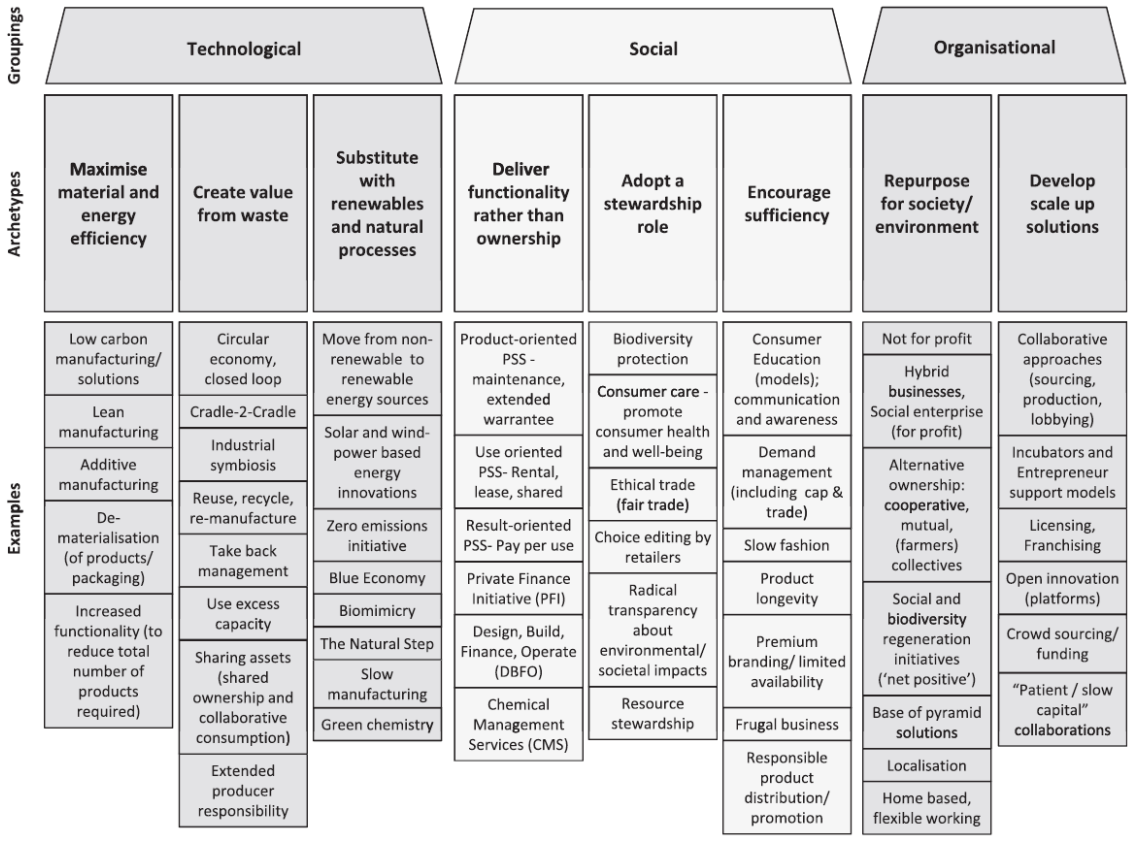

Figure 2.4: 8 archetypes of sustainable business models (Bocken et al., 2014)

In the end, there is roughly a consistency in the building blocks used for business model frameworks. Although some sources use fewer than 9 building blocks, these fewer building blocks are still in line with each other. Thus, the 9 building blocks can be used for this paper. However, when it comes to integrating sustainability or proposing actual business models, the literature is fragmented and there are many different approaches with no clear 'best' solution. Moreover, some of the business models (or archetypes) proposed may not always apply or if applied may lead to all or most manure niche firms landing in (for example) one category, which would not be beneficial for this analysis.

Therefore, it will likely be necessary to come up with new business model types that are tailored specifically to the manure processing and recycling niche. Such an approach has been taken before, where first the niche is analysed before the business models are determined. For example, Huijben and Verbong (2013) investigated PV panels in the Netherlands using SNM and business models and identified 3 business models: customer-owned, community shares and third party, which can be seen as a differentiation via the "revenue streams" business building block. Meanwhile, Hakim (2021) differentiated business models into state owned, private company, public-private partnership and cooperative, which can be seen as a differentiation via the "key partnerships" business building block. A similar approach will be taken in this paper, which will be elaborated on in chapter 3.

2.4 Manure-specific research

In order to further understand the problem and scope what already exists, research on manure processing and recycling innovations with regard to SNM and business models were investigated. After an initial search, no papers were discovered with an exact focus on SNM and business models in the manure processing and recycling niche. Therefore, the search was split up into 3 main parts. First, SNM-specific papers with a focus on more general manure and agriculture were investigated. Then business model-specific papers with a focus on more general manure and agriculture were investigated. Finally, general papers were investigated on the exact niche this paper aims to investigate (i.e. manure processing and recycling in agriculture), where the Dutch terms were also tried out ("mestverwerking").

i) SNM-focused papers on more general manure/agriculture:
When searching for literature on manure in combination with strategic niche management very little is found with regard to agriculture. This is because quite often manure is used as a part of the sustainable energy niche where manure is used as a form of biofuel in co-combustion or as biogas from manure digestion (Raven, 2005). In fact, after narrowing down the search to exclude 'energy' and 'biofuel', the results were reduced from over 1000 results to less than 90 and those that remain are either focused on sanitation, or in the cases where agriculture was the focus, the strategic niche management is on adopting sustainable farming practices in developing countries (Hegger, van Vliet, & van Vliet, 2007; Stuiver, 2006).

ii) Business model-focused papers on more general manure/agriculture:
When searching for more general business model papers in the manure and agriculture industry, just like with SNM, the focus is often on developing countries or the focus quickly deviates away from the core, like micro-cattle farms or the combination of tourism with livestock. However, fortunately one paper was found that was relevant to the intended research of this paper: circular business models for creating value from agro-waste (Donner, Gohier, & H., 2020). In this paper, 3 types of agro-waste are investigated together, namely manure, co-products from cereals and co-products from wines, where 5 possible usages were suggested for the waste: heat, bio-energy, bio-materials, food & feed, and specialty molecules. From this, 6 typologies are proposed, which can be seen in figure 2.5. However, this paper does not mention transition (except that transitions to circular business models are important), let alone niche transition or factors of SNM.

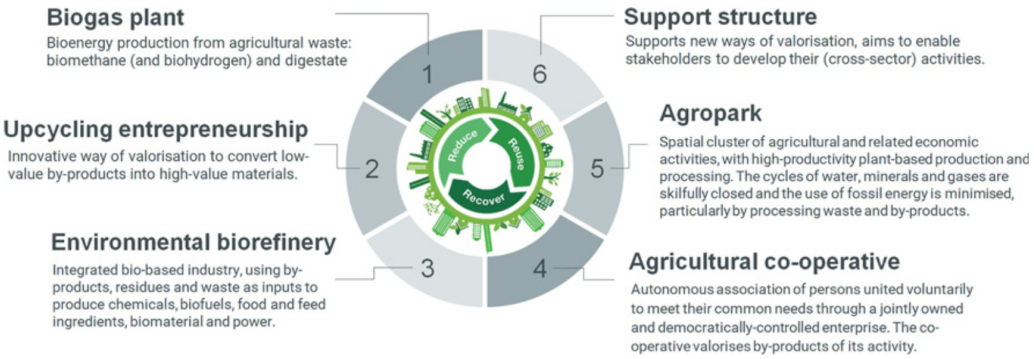

Figure 2.5: 6 proposed business model typologies for agro-waste (Donner et al., 2020)

iii) General papers on the exact manure processing niche:
Regarding the exact niche, there have been papers on the manure processing and recycling niche analysing the technical and financial feasibility, or analysing the environmental impact of these innovations, but these papers often do not talk about or only briefly mention transitions, let alone identifying recommendations to help these innovations (Verdoes et al., 2021). Similarly, there has also been limited dedicated research on the role of manure processing and recycling in a circular economy and the role of policies. These papers have a fairly basic analysis with simple conclusions such as that the negative manure price leads to possibilities for manure processing being more viable than before regulations were introduced (Woltjer & Smits, 2019).

However, these papers are still useful to an extent. Verdoes et.al. mentions that a technology can be identified by a 'technology readiness level', which is rated from 1 to 9 (Verdoes et al., 2021). A score of 1-3 indicates the technology is just discovered, 4-6 indicates development, 7-8 indicates that the technology is demonstrable (e.g. working prototype), while a score of 9 indicates the technology is deployed on the market. This can be used for identifying firms to interview, as firms that have deployed technology or at least demonstrable technology will likely make for better interview participants. On another note, Woltjer & Smits mentions that there is a surplus of phosphate in the Netherlands, so they suggested that there is a large market for exporting the phosphate-rich thick fraction abroad (Woltjer & Smits, 2019). With this, they suggested that firms are mainly split up into 5 manure processing options. Similarly, several other papers also suggested grouping of manure processing (firms) based on technologies, processes, and products made (Nederlands Centrum Mestverwaarding, 2020; NUTRIMAN, 2021; van Dijk et al., 2020; Verdoes et al., 2021). These will be discussed next.

2.4.1 Niche classifications and definition

Besides general information on the niche, several papers suggested methods to classify firms in the manure processing and recycling niche. These are generally split up into either the technologies/processes used and the final products made, where some papers even identified both. Although these technical classifications are not direct business models, it may be that different products or processes are more suited to different business styles. Therefore, identifying the different classifications will allow for a good basis to identify different types of actors for this paper, which in turn allows for a wide variety of interview participants (to be discussed more in section 3).

Verdoes et al. (2021) listed and analysed some of the niche firms and suggested 14 groups based on technologies used, where one firm can be in multiple groups at the same time, since one firm can use many technologies concurrently. Meanwhile, Woltjer and Smits (2019) defined only 5 main manure processing options with overlap, which is more focused on classifying existing firms and each firm can only fit in one of these classifications. van Dijk et al. (2020) deviated somewhat by instead focusing on the products made rather than the process itself and came up with 7 product-market combinations. Furthermore, the farmer platform from NUTRIMAN (2021) and the Dutch centre for manure valorisation classifies manure processing more in-depth by identifying both technologies used and the final products (Nederlands Centrum Mestverwaarding, 2020). An overview of the classifications can be seen in table 2.4.

Table 2.4: Overview of manure processing niche classifications according to literature

	Verdoes, et.al. 2021	**Woltjer, & Smits, 2019**	**Van Dijk, et al. 2020**	**NUTRIMAN, 2021**	**NCM, 2020**
Technologies or processes	-**M**echanical separation -**M**icrofiltration -**F**ermentation -**B**iogas production -**C**omposting -**B**iological N removal -**S**tripping/Scrubbing -**N**H3 Biofilter -**R**everse osmosis -**D**rying and evaporating -**P**yrolysis or gasification -**P**hosphate separation -**G**ranules/pellets -**P**re/after-treatment	-**O**nly manure separation -**S**eparation & composting the thick fraction -**S**eparation and granulating the thick fraction -**G**ranulating manure directly -**A**dvanced methods	N/A	-**B**iological nutrient recovery (Anaerobic digestion, Composting, algae/enzyme technology) -**P**hosphorus precipitation from liquid manure, waste water -**T**hermochemical nutrient recovery -**P**hysic-chemical nitrogen recovery (recovery from air, Chemical addition, membrane filtration, Stripping + Scrubbing, Physical separation)	-<u>Thin-thick separation</u> -<u>Thick fraction processing</u>: -**D**rying -**C**omposting -**G**ranulation -**G**asifying/combusting -**H**ygenisation -<u>Thin fraction processing</u>: -**B**io-treatment -**F**iltration -**R**everse osmosis -**S**tripping/scrubbing -**E**vaporation -**A**lgae -<u>**M**isc processes</u> -<u>No treatment</u>
Products	N/A	N/A	-**5**% N product -**2**0-25% N product -**5**% K product -**M**ineral P product, calcium phosphate -**D**ried P-holding product (85%+ solid) -**C**omposted P-holding product (50%+ solid) -**L**ow P product	-**C**ompost, Digestate and biomass -**A**sh -**S**truvite and other P-product (P-acid/ precipitate) -**B**iochar and Bio-Phosphate -**S**crubber water and mineral nitrogen concentrates: (scrubber water (NH3+H20), Ammonium nitrate/sulphate, mineral concentrate, solid manure, liquid manure)	-**T**hin fraction -**D**igestate -**T**hick fraction -**H**ygienised thick fraction -**C**ompost -**D**ried manure -**M**anure granules -**A**mmonium sulphate -**M**ineral concentrate -**O**thers

Note: N = nitrogen, P = phosphorus/phosphate, K = potassium

Some of these papers also had a list of example firms for their classifications. However, what is interesting to note is that all these papers only listed a relatively small number of firms as examples for the niche, totalling around 30 firms altogether (which are listed in the next sub-chapter), except for the study by the Dutch centre for manure valorisation. That paper alone identified a total of 136 manure processing firms in the Netherlands (Nederlands Centrum Mestverwaarding, 2020). This is due to them identifying manure processing firms as any firm that deals in manure and does something with it. In fact, of the firms they identified, 36% of firms did not do any manure separation, 40% do not process the thick fraction and 60% do not process the thin fraction at all (Nederlands Centrum Mestverwaarding, 2020). Most firms identified only did limited processing,

where selling dried manure, raw thin fraction and (hygienised) raw thick fraction accounted for the majority of products sold by firms. Also, only 22% of firms do not (partially) export their products to another country (Nederlands Centrum Mestverwaarding, 2020).

This leads to a rhetorical question of how does one define the manure processing and recycling niche? This paper aims to help innovating firms in the niche grow that also help reduce nitrogen emissions in the long run, so a firm that merely dries manure and exports it to another country, which accounts for a significant number of firms (Nederlands Centrum Mestverwaarding, 2020), should not be the focus to help in this paper, as it only temporarily moves the problem to another country. Similarly, Verdoes et al. (2021), van Dijk et al. (2020), and NUTRIMAN (2021) focus on the feasibility of the more advanced and potentially radical innovations in the niche for this reason. However, even these papers acknowledge the simpler processing methods as part of the niche. Thus, one can conclude that all manure processing and recycling firms count as the niche, even if they only barely process manure. Moreover, even if these simpler processing firms may not be the main focus of the outcome of this paper, it would still be wise to consider all firms as these firms will still have a good insight of the manure industry, regulations and whatever other factors may have an effect on the niche.

On a separate note, what was rarely mentioned in the papers from table 2.4 was that generally speaking a specific product uses a specific process or set of processes to make that product. For example, the stripping/scrubbing and/or reverse osmosis is almost exclusively used to refine the thin fraction into a mineral concentrate or liquid fertilizer of some sort. As such, it is possible to somewhat combine the technologies/processes and final products of table 2.4 to create a new list of classification. This classification can be seen next and will be used to classify identified firms in the following sub-chapter.

New proposed combined classification:

a) **Separation** (including filtration or other pre-treatment for separation)

b) **Thick fraction processing and products** (solid fertilizers, gas/energy)

- Composting/hygienisation
- Fermentation and biogas production
- Combustion/pyrolysis/biochar creation
- Drying/evaporating (applies to both thick and thin fraction)

c) **Thin fraction processing and products** (mineral concentrates, liquid fertilizers)

- Drying/evaporating (applies to both thick and thin fraction)
- Stripping and scrubbing
- Reverse osmosis/membranes

d) **Miscellaneous processes**

Certain processes or technologies have been excluded or combined with other technologies. For example, some firms sell regular dried manure, whereas other firms granulate the (dried) manure before selling, so that it is easier to use on a farmer's land. However, this granulation does not add significantly to the cost nor value proposition of a firm compared to larger dried chunks, so for the sake of simplicity, it is excluded. Similarly, 'separation' and 'filtration' is combined, since both aim to separate solid particles from a liquid. Also, often in cases where filtration is part of a later process, it is likely an additional step 'just in case' rather than a crucial part of the process.

2.4.2 Niche firms (actors)

Several sources mentioned previously in this paper were useful for the first round of identifying actors in the niche (Nederlands Centrum Mestverwaarding, 2020; NUTRIMAN, 2021; van Dijk et al., 2020; Verdoes et al., 2021; Woltjer & Smits, 2019). In order to further identify actors in the manure processing niche, government documents were also used. Within the Netherlands, a firm needs to be officially established and approved to be able to operate for certain activities, such as processing manure, or even transporting it. For this 4 government lists were identified from the Dutch Government's page of approved and registered animal by-products establishments, of which 3 were used (the intermediaries is discarded as they do not actually process manure):

- Intermediaries for transport and export: 1169 firms
- Manure-processing capable installations: 62 firms (Netherlands Food and Consumer Product Safety Authority, 2021b)
- Manure- and manure-residue capable biogas installations: 141 firms (Netherlands Food and Consumer Product Safety Authority, 2021a)
- Mineral concentrate producing-capable installations (pilot program): 10 listings/projects spread over 18 firms as some listings have 2 firms assigned to them, likely as part of a cooperative (Rijksdienst voor Ondernemend Nederland, 2021b)

Please keep in mind that there is a lot of overlap between these lists. For example, of the 62 manure processing capable installations, 33 were also listed in the intermediary list, 8 were listed in the biogas-capable list and 8 were listed in the mineral concentrate list (spread over 7 of the listings/projects). For the manure capable biogas installations only the biogas installations were included in the overview that have a relatively large focus on manure, since many installations focus on food and plant residues/left-overs and the manure that they do process is mostly very small quantities coming from household green containers.

Similarly, not all of these firms are useful or used in this paper. Of the 62 established manure processing capable firms, 21 firms had insufficient information available to classify them, mainly due to the majority of these 21 firms being small 1-person owned businesses (individual farms) without a website. Moreover, 4 were duplicate firms of the same establishment, but with different names and 2 were even bankrupt. A similar trend is observable for the other 2 lists.

After all the firms have been identified as well as general searching for manure processing and recycling firms, a list is compiled and sorted according to the created classification of the previous sub-chapter. This full list of all 110 identified firms can be seen organized by general processing

type in tables A.1 through A.5 in appendix A. These will mainly be firms and start-ups that are already established and at least in the late development/prototyping stage or later. Since there will always be people with unproven ideas or innovations in the pre-development phase where there are still a lot of unknowns and no business is established yet, these very early stage innovations will not be considered.

To very briefly summarise the 110 identified firms in the niche, the majority processed only the thick fraction in some way or made biogas, including 37 biogas-only firms, 25 composting- or hygienisation-only firms and 4 biochar related firms. On the other end of the spectrum, there were 14 firms that processed only the thin fraction. Meanwhile, there were 22 firms that processed both the thick and the thin fraction, where 12 did it in combination with biogas and 10 did it in combination with composting/hygienisation. Finally, there were 8 miscellaneous firms.It was also noticed that some firms offer a service to farmers of taking in manure, some offer the equipment or products for processing manure and some firms operate for their own use only, which is another level of differentiation that can be seen in appendix A.

It is useful to note that it is certainly possible for more firms to be in the niche than are listed in tables A.1 through A.5, especially for the equipment and machinery producers. This is because one farm can use equipment from many different suppliers and often multi-purpose equipment is used in multiple industries. For example, membrane manufacturers for reverse osmosis processes are used in anything from manure to desalination and the food industry. Even a decanter centrifuge, which is the most popular type of manure thick-thin separator equipment (Nederlands Centrum Mestverwaarding, 2020) is also used in the Petrochemical/oil industry, food industry and even polymer and synthetic rubber industry (Yaskawa, 2010). Thus, if equipment producers specific to livestock manure processing were found (not general manure/farm equipment), they were included, but the list can likely still be further expanded in the future.

Yet another thing to point out is that great care was also taken to try and prevent duplicate firms; however, this was easier said than done as sometimes the connections between firms were rather confusing. For example, VP Hobe makes equipment for manure processing. However, VP Hobe actually consists of 2 separate firms: HoBe BV in the town Luyksgestel and VP-Systems in the town America. Interestingly, the firm Agro America is situated at the exact same address as VP-Systems. Meanwhile, BTC de Peel is located in the town of Odiliapeel, but has their post-address listed on their website at also the same location in the town America. All of these are listed as separate companies and they show each other as 'partners' on their websites. Upon further investigation, BTC De Peel went bankrupt and Agro America bought their plant with help from Blue Sphere; a US firm that develops and operates waste-to-energy facilities and who now owns a part of BTC de Peel (Thelosen, 2021).

2.5 Knowledge gap & academic relevance

As evident from the literature review, the MLP and SNM are both well-established, even if there is some criticism on these frameworks. For business model frameworks, the basic concepts and building blocks are also well-established, although for business models, when introducing sustainability or creating business model typologies, the literature becomes more scattered and fragmented. Similarly, literature agrees that good business models are essential for niche

transition (Bidmon & Knab, 2018), but there is still little research on how elements from business models are connected to transition elements like that from SNM.

Also, quite some research has been done on analysing the technical, economic and environmental impact of manure processing and recycling innovations and several papers have tried to classify the niche by technologies, processes and final products. There has been even been some literature on the policy-side of manure processing and recycling innovations, which shows the need for such innovations to be adopted. However, as evident from the literature review, there is practically no research on the actual niche transition of these specific innovations or on business models for these start-ups. In essence, the 'final stepping stone' to help these types of innovations actually transition and be adopted in practice is missing.

Therefore this paper aims to help fill this knowledge gap by analysing the manure processing and recycling niche and creating recommendations to help start-ups come to fruition or to help them set-up the right business if they have a good innovation. Meanwhile, this paper will also contribute to the literature on SNM and business models, by offering an empirical case of niche transition, strengthening the relationship between these two factors and possibly giving new insights.

2.6 Summary of the literature review and background

The literature review investigated the different frameworks that are used in this paper. First, the Multi-Level Perspective (MLP) was investigated, developed by Geels (2002) and consisting of 3 reinforced levels: the macro (landscape) level, the meso (regime) level and the micro (niche) level (Geels et al., 2017). Although the MLP is not without its flaws, it is still well-suited to analysing the characteristics of transition (Geels, 2011). However, since the MLP has a small focus on the niche, Strategic Niche Management (SNM) is also investigated to have a further in-depth analysis, consisting of 3 main elements; shielding, nurturing, and empowering (Smith & Raven, 2012). Business model frameworks were also investigated, where a business model can be seen as a tool to express the firm's business logic (Osterwalder et al., 2005) and interpreted and visualised using 9 building blocks that are presented in a business model canvas (Osterwalder & Pigneur, 2010). However, although the building blocks generally coincide with each other in literature, when it comes to integrating sustainability, as well as identifying the business models themselves, the literature is fragmented, meaning that new business models will have to be defined in this paper.

Regarding manure niche specific research, although general technical and financial feasibility studies were found, there were actually no papers found on SNM or MLP related to the niche and only one somewhat relevant paper on business models. However, the general papers and government documents on the niche were very useful for classifying and identifying the niche. In the end, 110 firms were identified and classified using classifications from 5 key sources.

3 Research Methodology

This chapter will talk about how the research will be done, the analytical frameworks that will be used during this paper and how data collection will be done. The research of this paper will be a mix of exploratory research, to get an overview of the manure processing and recycling niche and its dynamics, and explanatory/descriptive research, to explain why certain firms use certain business models using SNM concepts and making business model recommendations. In order to conduct this research, both desk research and semi-structured interviews will be conducted and due to the nature of this research, this research will be predominantly qualitative, relying on insights from interviews and case studies.

3.1 Approach to research questions

The main research question is shown below, based on the objective of this paper. The sub-questions and the rationale behind each of the sub-questions, how they aim to be answered, and how they aim to contribute to answering the main research question, is discussed in the following paragraphs.

> *How is the manure processing and recycling niche in the Netherlands currently developing and how can business models help innovators in the niche succeed?*

To prepare for this main research question, an extensive list of the main players in the niche has already been made in the literature review. Later on in this methodology chapter these main players will be grouped/clustered together. As Donner et al. (2020) pointed out, manure can be processed or recycled into different substances and these may require different technologies. Similarly, different technologies may require different business model approaches, so by grouping the different products or technologies together, not only will a good overview of the players be made, it would be possible to get a nice variety of actors that likely have different business models. These groups will then form the basis to select interview participants from (i.e. via stratified sampling), ensuring that insights will be taken from the entire niche. Afterwards, the outcome of these interviews will be used (in combination with desk research) to answer the following sub-questions.

RQ 1: *What is the current socio-technical regime and landscape and how does it affect the niche?*
This sub-question aims to identify the outside forces and factors acting on and affecting the niche. It does so by investigating the socio-technical regime and landscape factors of the MLP via both desk-research and interviews. Stakeholders, policies, and more will be taken into account to see how it puts pressure on the niche, but landscape factors such as current global developments will also be taken into account, as it can not only put pressure on the niche, but also the regime, potentially allowing for a window of opportunity.

RQ 2: *How do current niche firms capture the benefits or tackle the problems of the regime and landscape?*
In a similar manner to the first sub-question, this aims to investigate the efforts by the niche and identify the internal niche activities during the development of manure innovations. For this, SNM will be used and it will also be a combination of desk research and interviews.

RQ 3: *What sort of business models do firms in the niche currently use?*
This sub-question is self-explanatory and the business model can be seen as another alternative way of how the firms or niche aims to develop. As mentioned at the end of the business model part of the literature review, it will likely be necessary to come up with new business models, so instead of immediately assigning a business model to each group/interviewee, first the 9 business model building blocks of Osterwalder and Pigneur (2010) will be identified for each of the interviewed niche firm and then afterwards the business models will be created. By the end of this, aided by the stratified sampling, hopefully a list of diverse business models used in the niche is identified.

After completing research sub-questions 1 through 3, all information is known to answer the first part of the main research question ("How is the manure processing and recycling niche in the Netherlands currently developing?").

RQ 4: *What trends and patterns arise from the niche and their business models and what sort of (business model) recommendations can be made to newly starting firms in the niche?*
This sub-question aims to take the outcome of the previous sub-questions and uses it to answer the second part of the main research question ("...how can business models help innovators in the niche succeed?"). By identifying patterns and making connections between SNM and business models, it is possible to identify why certain business models are more useful for certain technologies or firms and thus recommendations can be made to new firms starting in the niche. At the time of drafting this research, it is not known yet what sort of relationships or recommendations will be made, but it can be said that these recommendations are focused on helping start-ups in the niche.

It useful to point out here that an earlier draft of the main research question (before it was changed) was "What sort of business models do Dutch novel manure processing and recycling firms need to use in order to have the greatest chance of success?" However, this implies two things. First, to identify the best business models, an overview needs to be made of all business models. This is not feasible as one would not only need to identify all business models used by all current and past actors, but also all business models that have not been used yet, not to mention there is no agreement in literature on the types of business models. Secondly, to say one business model is the 'best' would require judging every business model against all relevant factors, which again is not feasible, especially since some factors may not have a full analysis or missing information. Thus, the aim of this paper is numbed a bit to find recommendations based on only the business models that are found and the relationships that are found as these will be the only ones where sufficient information is available for to draw reasonable and justifiable conclusions.

Finally, after these points have been handled, the results can be discussed with regard to validity and limitations, conclusions can be drawn, and recommendations can be made for future research.

3.2 Analytical framework

This section describes the framework that is made and used in this paper. For this framework, the 3 frameworks from the literature review are combined together, namely the MLP, SNM and business models. In this paper, business models for transition are a central component, but just seeing what sort of business models or business model building blocks a niche firm uses is not enough information to see why such a business model is used, nor does it say how it is a good business model. Thus,

more frameworks need to added to answer this "why?" which comes from both the outside factors and the thought-train of the niche actors themselves.

This is where the MLP comes in. The MLP aims to explain the "why" in the form of selection pressures and outside factors. However, since the niche analysis of the MLP framework does not describe the niche in much depth, nor does it explain the thoughts within the niche, the niche level of the MLP is replaced with the SNM framework, thus creating a new framework that explains niche transitions in more detail. Via a different train of thought, the MLP aims to explain the niche transition as happening due to outside factors, meaning that even a badly developed niche may cause transition if a window of opportunity arises. However, SNM says that transition happens due to the niche becoming competitive and transition would not necessarily happen if it is not empowered. Thus, by combining MLP and SNM, insights are taken from both the outside factors acting on the niche and the factors from within the niche.

Afterwards, the business model framework from Osterwalder and Pigneur (2010) is added next to the SNM framework to bring it all together into one analytical framework. With this analytical framework, this paper aims to understand the link between SNM and business models and once the "why" is understood, it will be possible to make business model recommendations to new start-ups in the niche. The analytical framework made for this paper can be seen in figure 3.1, and in the following subsections the components of this framework will be explained in more detail.

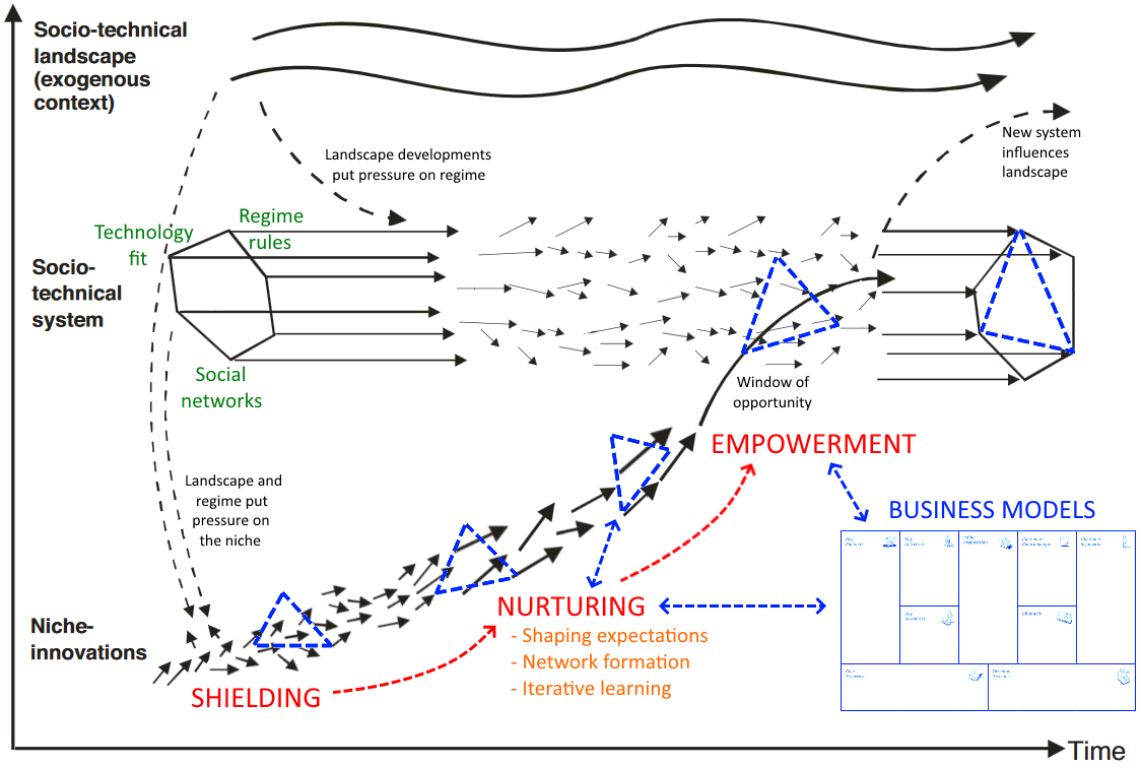

Figure 3.1: Integrated framework using MLP, SNM and business models (adapted from Geels (2019))

3.2.1 Landscape analysis

The landscape is about the 'bigger picture' developments and the macro-economic factors that affect both the regime and niche level. How landscape developments can affect the niche can be direct (e.g. international pressure on climate change, including nitrogen emissions, causing law changes) or indirect (e.g. an economic recession that reduces the output of all firms and thus also in the niche and its development). The landscape factors that can affect niche developments (e.g. climate change and demographic trends) and in what way will be discussed in this paper using information from interviews and desk research.

3.2.2 Socio-technical regime analysis

The socio-technical regime analysis is the 'middle-level' of the MLP and for this the analysis of factors can be split up in one of two ways: either via the original 7 elements from Geels (2002) (technology, markets, sectoral policy, techno-scientific knowledge, industrial networks, culture and infrastructure) or via the newer 3 interconnected dimensions (social network of actors, technology fit and regime rules), which is suggested by Verbong and Geels (2007). In this paper the second approach will be used as it allows for a clearer analysis than the 7 elements. For example, "techno-scientific knowledge" and "industrial networks" are both closely related, so writing separate sections would be difficult and also, finding "culture" factors that affect niche development would be very difficult. The 3 interconnected dimensions are explained in more detail below.

i) The social network of actors: here the actors and social groups will be investigated, how they are linked together, and how they affect the niche. This may include any actor ranging from academic institutions and local governments to competing firms and farms, as well as any other actor(s) that are found along the way that have an impact on the niche.

ii) The technology fit: here the technical aspects outside of the niche that have an effect are investigated, such as resources, infrastructure and technical elements.

iii) The regime rules: here the rules that guide action will be investigated. As mentioned during the literature review, the rules can be split up into 3 types: regulative (formal laws, sanctions), normative (values, duty, code of conduct), and cognitive (priorities, beliefs), however, since normative and cognitive rules will be very difficult to investigate and likely has a (much) smaller effect on the niche development, only the regulative rules will be investigated.

3.2.3 Niche analysis

As mentioned in the literature review, the niche analysis consists of 3 parts: niche shielding, nurturing and empowerment. These are explained next in more detail. The outcome of this is to gain a good understanding of the current development of the niche in the Netherlands.

i) Shielding:
The first aspect of niche analysis is in terms of active or passive shielding. Active shielding looks at how development of the niche can be protected through laws and regulations. For this, this paper will analyse Dutch laws on (nitrogen) emissions and manure usage, as well as regulations that protect and aid in the development of the niche (e.g. subsidies). Meanwhile, passive shielding

looks at development of the niche in an area where selection pressures are less intense. This paper will look at the proximity to incumbent firms and competitors to see if lock-in mechanisms exist, and the potential customers in the area. This part will conclude by seeing to what extent these two forms of shielding are present in the niche.

ii) Nurturing:
Nurturing the niche consists of 3 parts: the voicing and shaping of expectations, the formation of networks, and the iterative learning process. These will be explained below and an overview of these can also be found in Table 2.1 (Kamp & Vanheule, 2015).

Voicing and shaping of expectations: Two main types of expectations exist: internal expectations from actors within the niche itself and external expectations, which are expectations of the niche from outsiders. Since this paper will focus on the niche itself, only internal expectations will be analysed, since there will likely be insufficient data for external expectations. Furthermore, expectations can be classified into exogenous (originating from landscape and regime factors) and endogenous (originating from learning experiences) expectations. Both of these will be considered when gathering data from the interviewees.

Formation of networks: this can be approached using two parts. First, for the composition of networks, the actors within the niche, their role and how they are linked will be investigated to see if the size is good and if there are actors with traits that support each other. Secondly, for the alignment of networks, the vision, expectations and interactions of the network will be analysed to see if the actors are in-line with each other to support the niche development.

Iterative learning process: here the learning by the niche actors will be investigated. This is based on the 5 aspects identified by Hoogma et al. (2002), which was slightly expanded to 7 aspects by Kamp and Vanheule (2015).

- Technical development and infrastructure: learning how the technology for manure processing and recycling has been improving, as well as its support technologies and infrastructures.
- Industrial development and production: learning how the production and development to bring the innovation to (mass) production is improving, including maintenance for these systems.
- Development of user context: learning what the end-user characteristics are, how they will use the product (e.g. ease of use) and what requirements they need to use it (e.g. education).
- Societal and environmental impact: learning how safe the technology is, what the environmental impact is, as well as the social impact of the technology.
- Government regulations and policies: learning how laws and policies affect their firm and innovation, including incentives and subsidies that aid in the development and adoption.
- Resource potential: learning what resources are available (e.g. all the different nutrients within manure) and how they can be harnessed or captured.
- Business models: learning about the effectiveness of their business model and how it can be changed to improve competitiveness and adoption of the niche.

iii) Empowerment:
If the niche is properly shielded and nurtured, it can finally be empowered. This can happen via 2 ways: either the niche innovator 'fits and conforms' or it 'stretches and transforms'. In the fit and conform approach the niche becomes competitive in an unchanged regime, whereas for the stretch and transform approach the regime has to change for the niche to become competitive, such as through regulatory and law changes. This paper will look to what extents both of these approaches are applicable to the manure processing and recycling niche by looking into if laws changed in the Netherlands or if firms in the niche tried new ways of dealing with regime problems (to conform).

3.2.4 Business model analysis:

Besides the niche analysis, how firms in the niche aim to deal with outside factors can also be described using business models. By also looking at the actions within the niche from the business model perspective, a stronger understanding can be made of why the niche acts the way they do and how they can put pressure on the existing regime to allow for transition. It may even be possible to link certain aspects of SNM to business models.

For the business model analysis, the business model canvas from Osterwalder and Pigneur (2010) will be used. Initially, the expanded business model canvas by Lewandowski (2016) was planned to be used, as it adds 2 elements related to sustainability transition. However, the first of these elements; adoption factors (external factors that support transition), is already included in this paper in the form of the regime and landscape analysis. Meanwhile, the second element, the take-back system, which focuses on channels and ways to take back used products from the consumer to recycle it in a circular manner, is indirectly included in the value proposition for this paper, as the manure being reused and recycled is already a form of 'take back' system. Thus, the extended business model canvas will not add much and the original one with the 9 business model building blocks will be used, which allows the diverse number of business models to be examined in detail.

3.2.5 Overview of framework indicators

Since all the different indicators and terms can be overwhelming and confusing, especially since some of them are on different levels, all the indicators and their levels have been summarised in and overview in figure 3.2 on the next page.

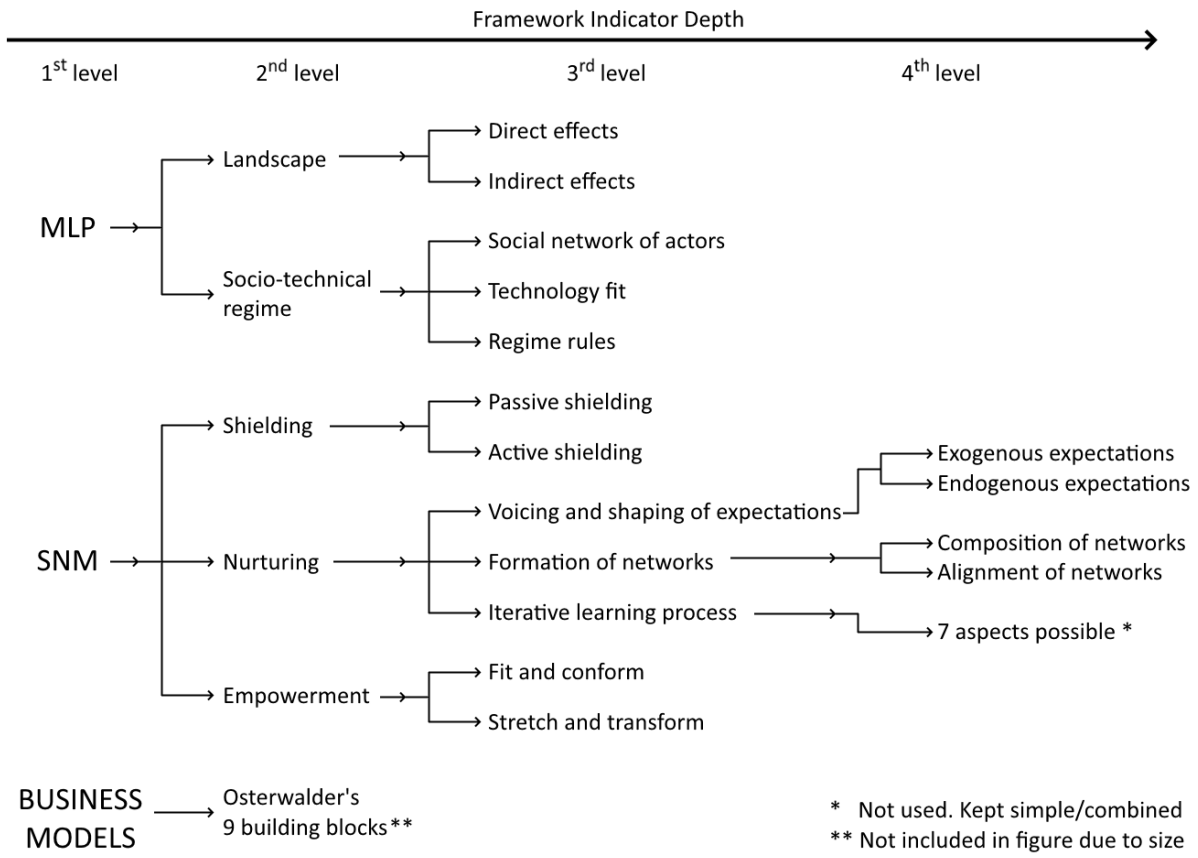

Figure 3.2: Overview of indicators and their depth levels used in the framework

3.3 Data collection

As alluded to before, data collection will happen via two main ways: desk research and interviews. The following subsections will elaborate on this in more detail.

3.3.1 Desk research

Desk research will be used for much of the data that does not come from the niche itself (such as the landscape) and for the initial scouting of the niche. For this, sources such as government laws and policies, reports, scientific literature, newspapers and the niche's firm's websites can be used. If possible, academic sources will take priority, where Google Scholar and SCOPUS will predominantly be used to ensure authenticity and reliability. Moreover, since the focus region is the Netherlands, Dutch sources and searches in Dutch can be used to further extend the pool of available data. However, since desk research is not enough to fully grasp the niche and there is little recorded information available on it, additional sourcing is necessary in the form of interviews.

3.3.2 Interviews

Interviews will predominantly be used to gather data on the niche and to build up a case study of a certain niche technology or group. One benefit of interviews over other methods (like surveys or observations) is that it is good for collecting qualitative data in high detail and it allows for clarification (Rowley, 2012). There are generally three types of interviews: structured, semi-structured and unstructured. For this paper, semi-structured interviews will be used.

Since this paper is more on the exploratory side, a semi-structured interview allows for more open-ended freedom to talk about unanticipated factors than a structured interview would, while still being structured enough that comparison between participants is possible, which is desired in this paper for distinguishing between actors in the niche. However, semi-structured interviews are not without their drawbacks. Of all data collection types and even within interview types it is the most time consuming, requiring time for planning, execution, transcribing and codifying. Also, knowledge on the topic is required for a good discussion, especially since semi-structured interviews only allow for a small number of participants (typically around 10), so pressure is put on making good interviews (Rowley, 2012).

The interview consists of pre-defined questions to get the conversation going and to collect the data needed to compare the different niche actors (e.g. asking about the 9 business model building blocks and asking about the regime and niche factors). However, some of the questions are fairly elastic and open-ended to further extend the discussion to gather more insights. The interviews will end with some open ended questions on what they think should change in the manure-processing niche and what recommendations they have for new start-ups in the niche.

3.3.3 Interview steps and protocol

First, the interview questions are made, along with organizational documents mentioning the purpose, usage, rights and ethics. This is first sent to the thesis supervisor and the ethics committee (HREC) to check and confirm. Once confirmed, the potential participants will be contacted and if they agree to an interview, the questions and organizational documents will be sent to them. Once a time-slot is planned for the interview, the interview can occur, which will be recorded.

Also, since this paper will talk about the business models used of several participating firms, the interview participants will be asked if they can be named in this project or if they want to be anonymous, not only for their privacy, but for potential competition reasons between firms. Formal consent will always be asked before the interviews and finally, if the participant wishes to stop or leave the interview at any point, they are free to do so. The information sheet of the protocol, as well as an overview of the questions used for the interviews can be found in appendix B.

As per the stricter data handling regulations in effect from academic year 2021-2022 onward, data storage now also has a specific protocol. The data and recordings are kept on the researcher's TU Delft OneDrive, with a separate storage for the informed consent forms, complying with the data handling requirements and ensuring the data is kept safely. All the data will be automatically deleted approximately 10 days after completion of the project with the exception of this paper and the anonymised transcripts, which may be retained by the TU Delft.

3.3.4 Data processing and analysis

After the interviews have been completed, the interviews will be transcribed as soon as possible to prevent loss of interpretation. To transcribe the interviews, first Microsoft Team's speech-to-text transcription is used, which is encrypted, and by using a TU Delft account, it should ensure privacy and data compliance; something which cannot be ensured by lesser transcription software. However, since the transcription is not always accurate, especially for cases where participants had a heavy rural accent, every single transcript was manually checked word for word and sometimes (partially) manually written to be fully correct.

Next, each transcript is read through manually and all of the relevant points mentioned during the interview related to this research is noted down into a much shorter and simpler 'notes' document. This notes document has the points categorised per interview question, and since the interview questions already roughly align with the different levels and indicators mentioned in figure 3.2, it means that it is also then manually coded by theme. At this stage, some of the points are also moved around between the different questions, because some responses to certain questions actually fit better by other questions/themes. After the notes document has been made, every point is transferred to their relevant location in the draft version of this thesis paper, where similar points mentioned by different participants are grouped together. With all these points in one place, they can then finally be analysed and combined to find insights and to be able to write a coherent piece.

3.3.5 Participant selection and influence

To be able to gain the most insights possible, a diverse group of participants is desired. For this, stratified sampling will be used for selecting the interview participants to try and achieve as many different business models and different insights from technologies in the niche as possible, as mentioned before. However, nothing has been mentioned yet on how to select a participant from within a certain technology group/cluster.

Selecting the right participants within clusters is very important, because, especially with relatively few participants overall, the participants can heavily influence the outcome and analysis of this paper and different participants may lead to completely different conclusions. One could focus on large or small firms, successful and unsuccessful firms, firms that have been established for a long time or only recently started, or a combination of these. Successful firms will allow one to identify patterns of what one should do to achieve success, whereas unsuccessful firms may have more insights on what not to do. Meanwhile, longer established firms may have more experience and knowledge built up, whereas younger firms may have more radical and innovative thoughts. Finally size can also be an indicator for success and how large a firm has grown.

Ultimately, the choice was made to focus on successful firms as they most likely have more knowledge and expertise and their insights are likely to be more useful than those of unsuccessful firms. Since it is difficult to determine what firms are successful or not at a glance or from online sources, judgement sampling will be used, where longer established and larger firms are preferred, since successful firms would have likely grown more and stayed in business for longer. Finally, if within a technology/product cluster no clear firm comes out on top, convenience sampling will be used.

3.3.6 Defining the niche groups/clusters

Up until now a list of the key players has been made and it has been mentioned that interview participants are selected from groups/clusters. However, these groups have not been defined yet, which will be done in this sub-chapter. Based on all the found firms in tables A.1 through A.5, there were 3 main differentiating factors between firms:

- **Technology/Output:** In a broad sense, the technology can be split up into thick-fraction processing technology and thin-fraction processing technology. Going deeper, the thick fraction technology can be further split up into biochar related technology, biogas related technology and compost/hygienised/dried manure. Meanwhile, the thin-fraction technology often relies on some form of reverse osmosis, stripping/scrubbing and/or drying, or it uses some 'secret' technology, but there are no very clear groups, with these technologies being used in various different configurations. Finally, separation equipment is used by some companies, depending on the technological need and on the vertical integration.
- **Vertical Integration:** Certain firms choose to do more or less of the manure processing. For example, separating manure is often one of the first steps of processing manure (except for fermentation for biogas where it is not needed), but not all firms separate themselves. Notably, smaller firms (especially individual farms) tend to not have the size to feasibly separate manure themselves and more often rely on mobile manure separation services. Similarly, the firms that process (and make equipment for) both the thick and the thin fraction tend to be larger firms and coincidentally, all firms that process both also have manure separation capabilities.
- **Product/Service/Own usage:** Some firms produce the products/equipment for manure processing (P), whereas other firms actually use that equipment to process the manure, thus offering a service for farmers to dispose of their manure (S). Similarly, some firms use the equipment to only process their own manure and do not have excess capacity (O).

Moreover, from creating and analysing the list of all observed actors in the niche, there were several observable points:

- There were far more firms using manure processing equipment than there are that make them (ratio of around 5:1). This is logical as one equipment manufacturer can make equipment for many farms and processing plants.
- There were many more large central processing plants and farms that process manure of farmers in the area than there were farms that only processed their own manure. This is likely due to the high price of manure processing equipment requiring economies of scale to make it financially feasible.
- A few farms even chose to develop their own manure processing technology or custom-made equipment rather than use one of the equipment producers. Although at this point just speculation, this might be due to the vast differences in requirements from farms (daily processing capacity, manure type, preferred process outcome) where there are not enough equipment producing firms to cover every need.

- There were many firms that only did very basic manure processing in the form of composting or hygienisation for the purpose of exporting it to another EU country. In fact, even just manure transportation and intermediaries far outweighed the actual processing firms.
- Certain technologies have overlap with other industries. For example, although biogas plants sometimes only ferment manure (mono-fermentation), often manure is fermented in combination with bio-waste such as crop residues and the contents of household green-containers. Similarly, there is an overlap of thin fraction processing equipment and plants with water treatment, as both have the aim to extract nutrients from the stream.

Taking all the differentiating factors and observable points into consideration, it is possible to make a map of the different types of actors in the niche, which is visible in figure 3.3. The numeric value next to each actor box indicates how many actors there are for that specific classification. For example. the "5 manure service" box in the middle green area indicates that there are 5 firms offering the service to process the manure thick and thin fraction, where the thick fraction gets processed using composting/hygienisation. Also, occasionally a firm may offer both a product and a service (3 firms in total), so for these cases instead of making the map more cluttered, they were counted for both separate actor boxes, which is why the total adds to 113 instead of the 110 identified firms. Similarly, the 8 miscellaneous firms accounts for the firms that could not be classified anywhere else, including 2 advice firms and 6 equipment producers of mostly manure separators.

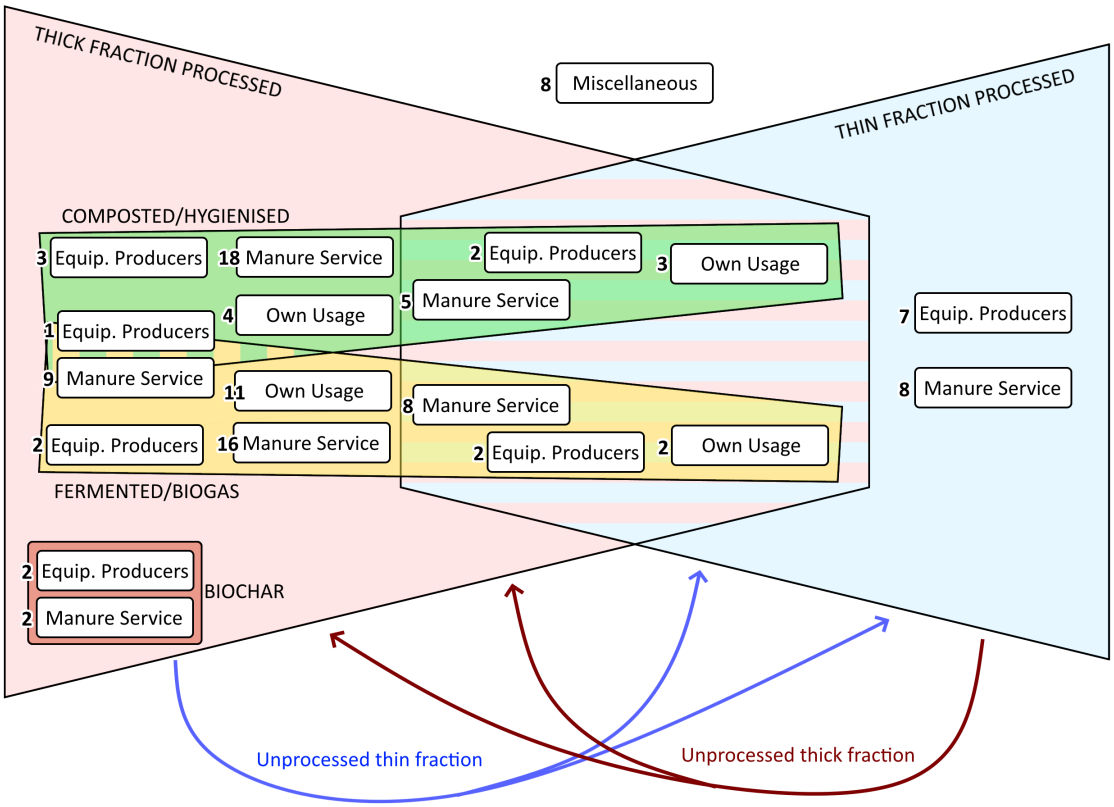

Figure 3.3: Overview of the different types of key actors in the niche

3.3.7 Interview participants and details

The actor map of figure 3.3 will form the basis for selecting interview participants, as these differentiating factors may also be related to how business models of these firms differ. Since the focus of this paper is to help innovative start-ups in the niche, particularly those that contribute to reducing nitrogen emissions, the interview selection has a heavier weight placed on firms that process manure further with more value extraction rather than the simpler (e.g. composting/ hygienisation and export) firms that do not contribute as much to lowering nitrogen emissions. Because of this, far fewer than the total 110 identified firms were contacted. In fact, when removing the export-focused firms, firms that had no contact information, firms that only processed a small fraction of manure (i.e. manure is not their main driver, which was the case for most biogas-only firms), firms that were eventually involved in some form of scandal/fraud, and firms that were not deemed suitable for any other miscellaneous reason, only 31 fully suitable participants were identified and contacted.

Of the 31 contacted firms who were emailed, reminded (sometimes twice) and sometimes called, 14 responded in some way and eventually 8 interviews were made. The basic information of the final chosen firms can be found in table 3.1. Since the response rate was below 100% (approximately 45% for replying and 26% for interviews), not all preferred firms were interviewed. However, this should not be a problem, as enough (large and successful) firms were identified so that a good analysis can still be made. One interview participant informally noted that they sometimes get multiple requests for interviews and surveys each week, so a low response rate is to be expected in this industry.

Table 3.1: Interview participants and relevant details

Firm name:	Brief summary of participating firm:	Reference ID:
Anonymous	Farm & full processing installation cooperation	I1
Kempfarm	Farm, processor, and large full system producer	I2
MEZT	Technology developer and systems producer	I3
Colsen	International technology developer	I4
Vlako	Farm and large independent processing installation	I5
Mestac	Full processing installation cooperation	I6
Twence	Large full processing and biogas firm	I7
NCM	Foundation & contact point for manure processing	I8

Overall the interviews went well. With the exception of one participant who preferred a phone call, all interviews were carried out via Microsoft Teams and no technical issues were encountered. All of the interviews were carried out in Dutch and within the time limit and for the participants that were particularly talkative, their questions were occasionally combined together to ensure it stays within the time limit (several participants had appointments after the interviews) and priority was given to the business model questions in case time threatened some questions to be cut off.

Finally, for the next chapters, the interviewed firms will be referenced by their reference ID in square brackets (e.g. [I3]) instead of full firm name to prevent cluttered references when the same point is mentioned by multiple participants, and to clearly distinguish it from traditional sources.

4 The Multi-Level-Perspective

4.1 Landscape analysis

The landscape is the broadest level of the MLP and containers factors that are part of the 'bigger picture' such as macro-economic factors. The landscape is split up into direct factors which immediately have an effect on the niche (in this case climate change) or indirect, where there is no direct effect, but there are secondary effects (such as an economic crisis).

4.1.1 Climate change, awareness & animal welfare

Arguably the largest landscape factor is that of climate change. Although climate change often focuses primarily on global warming and CO_2 emissions, nitrogen emissions are still a significant contributor. In fact, one participant noted that 87% of nitrogen emissions within agriculture comes from manure [I8]. The United Nations stated that "nitrogen management is key for climate change mitigation" since nitrous oxide can be a vastly (300 times) more potent greenhouse gas than carbon dioxide (United Nations, 2019).

Concerns about climate change have been around for decades, but it has accelerated in the 21^{st} century and in 2015 this resulted in the United Nation's Paris Climate Agreement. The Paris Climate Agreement is an international treaty signed by almost every nation in the world to limit global warming, primarily by reducing greenhouse emissions and thus also nitrogen emissions to an extent (United Nations, 2016).

Awareness by the general public has also increased, not only in the Netherlands, but also the rest of the world, and more of the public is trying to live in a more environmentally friendly and sustainable manner, which can be shown in figure 4.1 on the next page. In line with that, one can speculate that the public would like to also reduce nitrogen emissions, as it also contributes to the environment. Thus, since the manure processing industry aids in reducing emissions, the increased awareness might help out the industry.

However, animal welfare may also play a role. The public and certain political parties seek to give animals better lives and reduce suffering. This may not have a direct effect, but it does have an indirect effect on the industry. For example, the Dutch party 'Partij voor de Dieren' (PvdD) states on their website that they are against manure processing installations since it will only result in a higher livestock amount and more concentrated stables in the Netherlands where the animals do not live a great life. Instead, they say they want to reduce the amount of livestock, which not only reduces the amount of suffering, it tackles the nitrogen problem at the source since less manure is made in the first place (Partij voor de Dieren, 2022). Along similar lines, the livestock industry as a whole may be under shot by animal rights activists, which in turn also affects the manure processing industry. Thus, a strong public view of animal welfare may actually hinder the industry somewhat too.

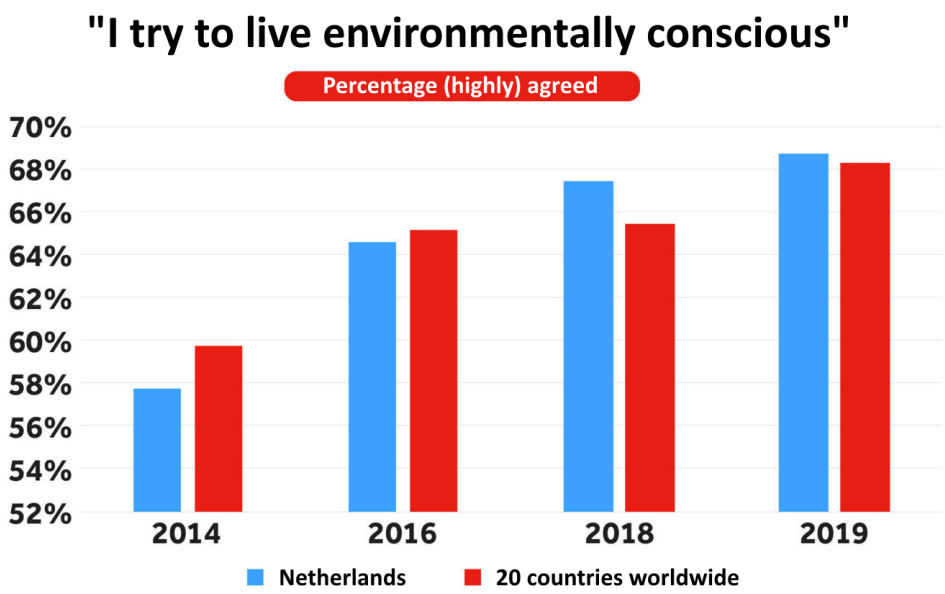

Figure 4.1: Percentage of Dutch population trying to live environmentally conscious (NOS, 2019a)

Although the awareness is increasing, it still has a long way to go. Some of the interview participants noted that manure processing is not a 'hot topic' and thus often left out of the media and not covered [I1, I2]. One participant even noted that "Even the word stinks!" [I2]. However, the pressure on the greenhouse gas emission reduction is only going to get larger and a change will eventually happen [I3]. One participant even pointed out that every time something climate change related is happening (e.g. in the news), it gives a slight boost in sales, especially when in combination with biogas [I4]. There is even some CO_2 reduction, since you are reducing unnecessary manure transportation to other locations by processing the manure into separate substances [I7]. Interestingly, none of the participants pointed out anything related to animal welfare or it having an effect, but it was informally noted that many farmers do love their animals and want the best for them.

4.1.2 2019 Nitrogen crisis

Climate change traditionally focuses on global warming, however, the disruption of ecosystems, (river) contamination and dwindling biodiversity is often also considered as being part of it and nitrogen emissions do contribute significantly to these environmental issues. Because of this, the Netherlands developed a strategy to specifically tackle the nitrogen problem.

However, after research came forth in early 2019 it was discovered that the then current nitrogen plan of the Netherlands breached the EU laws (Rijksoverheid RIVM, 2022). This was a problem because besides breaching EU laws, it raised concerns of the nitrogen deposits bringing too much nitrogen into areas that traditionally have little nutrients (including nitrogen), which would drive out local flora and fauna that thrived better with fewer nutrients and reduce biodiversity (van Dongen & Voermans, 2019). Thus, the 'Raad van State' (RvS) made a decision soon after on the 'Programma Aanpak Stikstof' (PAS) in 2019, which halted and cancelled permits to some 18,000

construction projects in Natura 2000 areas that would increase nitrogen deposits (Raad van State, 2019). It was also noted that the agricultural sector is the largest contributor at 46% (Rijksoverheid RIVM, 2019) and that ammonia emissions from intensive livestock farming is the key contributor for deposits within this (Hoogerbrugge et al., 2019).

Interestingly, upon further research nitrogen deposits have actually decreased since 1990 (right after the first regulations regarding nitrogen were introduced) and only stagnated or risen marginally since 2009, as seen in figure 4.2. Yet, the agricultural industry still fell victim to needing to further reduce their emissions. One possible argument is that due to the time between discovering the Netherlands did not meet EU laws and the updated PAS being so short, there was possibly some form of panic which led to drastic (and potentially rushed) decisions. This in combination with the agricultural industry not having a strong representative in the government (for example, the political party BoerenBurgerBeweging (BBB) did not exist until after the PAS was updated in 2019 and even now only holds less than 1% of votes) meant that the agricultural industry was possibly unable to properly defend themselves during lobbying to reduce nitrogen emissions, which may have led to them getting an unfavourable outcome. One of the participants noted that in fact it was the discovery of how severe the nitrogen deposits were to the environment that really triggered the crisis [I3], which somewhat backs up this idea of quick and potentially rushed decisions.

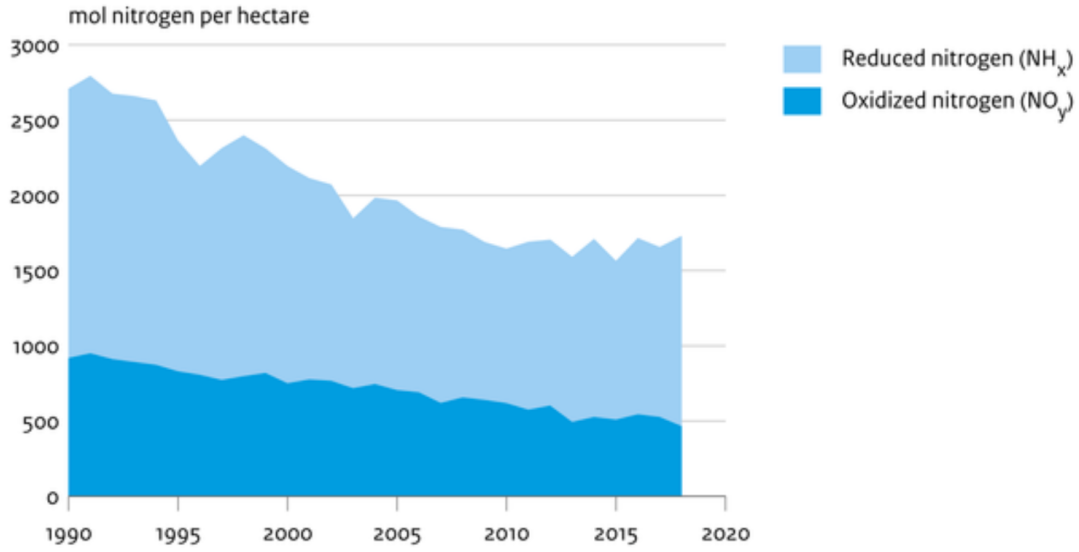

Figure 4.2: Overview of the average Dutch nitrogen deposits over time (Hoogerbrugge et al., 2019)

4.1.3 2008 Economic crisis

At first thought one would think that the 2008 economic crisis would have an (indirect) effect on the manure processing niche, but this is not really the case. People always need to eat and food (including meat) can be seen as a basic necessity. Although the economic crisis did have an effect on agriculture in the poorest areas of the world, in the Western world agriculture was barely impacted (Lin & Martin, 2010). This can also be seen in figure 4.3, where Europe's meat

production (of which a significant portion is produced by the Netherlands and thus directly related to manure production) has not been affected by the economic crisis. In fact, meat production kept on increasing year-on-year throughout the economic crisis as well when inspecting annual values (Ritchie & Roser, 2017).

Directly related to this, the manure processing niche would also not be as affected by the economic crisis, with steady manure supply and demand. Confirming this, the interview participants noted that the economic crisis has had no significant effect on them [I1, I2, I6]. After all, a cow still poops during a crisis and thus manure processing will continue [I6].

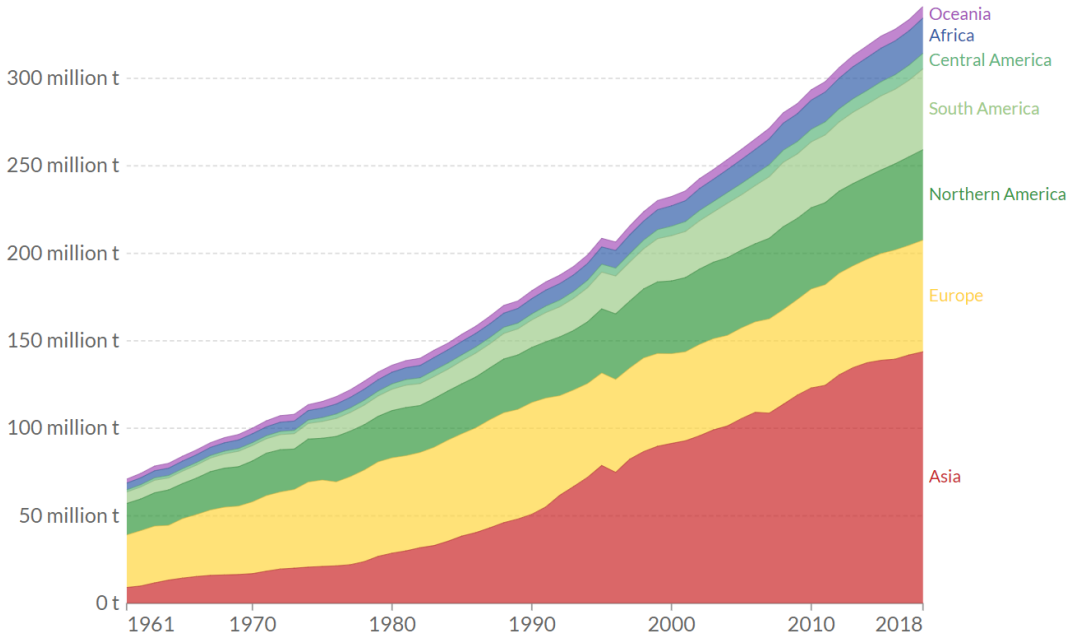

Figure 4.3: Global meat production over time per region (Ritchie & Roser, 2017)

4.1.4 Covid-19

In a similar manner, the Covid-19 pandemic also did not have a big effect, although it was slightly larger than the economic crisis. Farms generally could still continue on working and were more isolated from the pandemic and as such many participants noted that Covid had little to no effect and if there was an effect it was still reasonable [I1, I2, I3, I4, I6]. However, one participant who has international operations said that Covid did have a big effect on being able to sell international systems, because they often want to physically see one of their systems in the Netherlands before purchasing, but this is very difficult and frequently delayed [I4]. Another participant was also somewhat affected, since Covid slowed down the construction of their new installation and they couldn't be there in person to oversee it, but besides that they were not very affected [I7].

Also, outside of the interviews, the closing of catering and restaurants resulted in a lower demand for the goods of some farmers. One farmer noted that the closing of catering reduced the demand

for fries and milk, lowering their market price, and another said that they sell much less of their high-end beef to hotels and catering, thus forcing them to sell it to mainstream markets at regular bulk prices, reducing profits (Welink, 2020). This was backed up by one of the participants who noted that some of the members of his cooperation couldn't earn or deliver their goods as well, slightly reducing earnings, but this was still within a reasonable extent [I6].

However, these sorts of event are not out of the ordinary, and several participants noted that occasionally having a bad year is not uncommon [I1, I2] and that these macroeconomic factors having an effect on the market prices is to be expected and run of the mill [I4, I6]. Nonetheless, the uncertainty of Covid-19 in the future and how long it might go on for was a concern of some (Welink, 2020) [I1, I2] and that other factors such as permits, resource prices and the uncertainty surrounding nitrogen regulations have a much larger effect (Welink, 2020) [I1, I2, I3, I4].

4.1.5 Natural resource trends

Unlike Covid-19 and the 2008 economic crisis, the price fluctuations of natural resources have had a very large effect. Especially gas prices, which have increased by a factor of 5 in the last year has had a huge effect [I1, I6].

On the one hand, the higher gas prices made heating farms more expensive and increased the costs of some manure processing installations, but on the other hand it allows the final mineral concentrate products to be more competitive [I1, I3, I6, I7]. This is because before large artificial fertilizer firms using huge amounts of natural gas (up to 8% of all gas in the Netherlands [I1]) got incentives and lower bulk gas prices to stimulate the economy as well as lower tax brackets, which in turns allowed them to sell the artificial fertilizers at lower prices and made it difficult for mineral concentrates to compete [I1]. However, with the high gas prices these big factories are running at reduced capacity or even completely stopped as they cannot compete with international imported fertilizers, which raises the fertilizer price and increases the competitiveness of mineral concentrates [I1, I6]. Another participant agrees and speculates that mineral prices are likely to increase in the future [I8].

However, one participant did not have an overall benefit from this. Participant 7 has a fermentation installation producing biogas, but they have a special subsidised contract, where they sell their biogas at market price, which is then filled up with subsidies up to a final predetermined price [I7]. With the higher gas prices it just meant that their sale price got subsidised less, so they do not actually receive more revenue. However, the rising gas and electricity prices did increase their operating costs, so overall they are actually earning less than before [I7]. This contract was to ensure consistency and certainty for the long term and protects them from large drops in biogas prices and seasonal effects, but it also means they cannot capture the benefits in this case.

Similarly, the prices of certain chemicals or flocculants used in processing can increase or decrease and global factors may also further affect the cost of the final mineral concentrates [I1]. Even the manure disposal price/cost itself and diesel fuel can change due to various reasons, leading to changes in profitability. One participant noted that rising chemical and construction prices (which increased by 20% over the past year) has put a lot of pressure on his new installation [I7]. However, it was noted by many that this is expected and sometimes there can be major changes in as little as half a year [I1, I6].

Regarding minerals, one participant noted that in the future minerals could be a very valuable resource [I1]. For example, although the Netherlands has an excess of phosphate, which is often exported in the thick fraction or as compost, other parts of Europe and the rest of the world have a significant phosphate shortage [I1]. At the end of the day, minerals are essential for fertilizers, which are in turn essential for food production, which every country needs. Meanwhile, China and Russia are buying phosphate mines globally and he expects mineral prices (as well as food prices) to increase in the future [I1]. Thus, that participant noted that processing manure was almost like their duty to ensure that the minerals are not wasted or dissipated into the air to try and reduce a potential crisis from happening in the future, or as he puts it "Wars in the future will be for minerals" [I1].

4.2 Socio-technical regime analysis

The regime is the 'middle' level analysis, meaning that it has factors that are directly related to the niche, but that are not necessarily actually part of the niche. The regime level originally has 7 aspects, but as explained during the methodology, the alternative approach of 3 interconnected dimensions is used instead. These are handled in the following subsections.

4.2.1 Social network of actors (Stakeholders)

Within the literature review and background section, the main actors in the manure processing and recycling niche have been identified, being the technology producers, and farmers/central processing plants using the technology. However, there are more actors and interactions between actors than just within the specific niche itself. Therefore, all stakeholders in the general socio-technical regime who have an interaction with the niche will be discussed next.

i. Manure processing technology producers: These are arguably the most important actors in the niche as without them the manure processing niche would not exist. In essence one of the main goals of these producers is to generate a profitable income as most often these are private firms. However, sometimes the founders of these firms have a desire to help out the environment too [I2, I3]. Being a key stakeholder, the technology producers have close interactions with research institutions to develop the technology, the government to aid and for financing (via subsidies), as well as farmers who often purchase and use the technology. Occasionally the technology producers also create a central processing plant themselves or other non-farming firms start a central processing plant. Because the technology producers will try to sell their technology, they will also face competition from other technology producers in the niche, however, some pointed out that this competition is limited as there is not a very large market for system producers currently [I2, I4].

ii. Research institutions: Oftentimes new technologies that are used by the technology producers are developed either by or in collaboration with research institutions (such as universities). One could argue that as technology gets more mature there is less to be discovered (e.g. the simple composting methods), however, this is not always the case, especially for the thin fraction processing, where (for example) advances in membrane technology still occurs [I3]. Research institutions also evaluate the environmental impact of new technologies (sometimes as a task given by the government) meaning that there is still a lot of connection and collaboration between research institutions and other stakeholders.

iii. Farmers and manure processing plants: These are the main customers for the manure processing technology. Although regular farmers who do not process manure exist, most manure processing installations are on farms and run by farmers, so separating the farmers from the processing plants would be difficult. Their main desires are to have a well-working system that allows them to reduce costs (or increase profits) while also reducing emissions. It has been noted that farmers tend to work with fairly narrow profit margins, meaning that although farmers would really like to reduce their emissions, it should be at least cost neutral for them to adopt the technology or system [I2].

iv. Manure export firms: Currently, these firms are big players exporting excess manure to other countries or farms and at the moment there is little interaction between these firms and other stakeholders (besides farmers). However, this might change in the future as the manure processing would take away their business or if the livestock market shrinks [I4, I8], since manure processing can contribute to a circular economy, re-using manure in some form within the Netherlands rather than exporting it. One participant even originated from a distribution/transport service and believes that in the future such firms cannot survive on distribution alone [I6].

v. Government and municipalities: This can essentially be subdivided further into anything from local governments where manure processing plants exist to national ministries of health and safety to national governmental bodies offering subsidies (e.g. RVO), but for this section they will all be combined as their general interactions and desires are the same. Health and safety, as well as environmental impact are of a big concern for the government. Thus, they interact through laws and approval with the manure processing niche, regulating what technologies are allowed and limiting the negative (side)effects, but also by promoting innovative solutions through support (subsidies). However, as noted by almost all participants in one way or another, although the basic idea is good, the execution leaves much to be desired (which will be discussed later on).

vi. Gas and electricity providers: These have a generally smaller interest in the manure processing niche. Some forms of processing manure produces biogas which is then either sold to the gas grid or used directly to produce electricity, which is sold to the power grid/providers. However, it only counts for a small part of the grid, with all 'green' gas only accounting for roughly 1% of all gas in the Netherlands in 2018 (Alliander, 2019). Nonetheless, during the niche actor review it was discovered that some natural gas firms are teaming up with biogas producers, such as the GasUnie with Torrgas (one of the identified biochar producers). In fact, one participant noted there is a movement to replace natural gas, where the largest feed-stock source for green gas in the Netherlands is manure [I8].

vii. Waste water processing plants: Much like the gas and electricity providers, the water processing plants have a smaller, but still evident, interest. Since technology for processing the thin fraction of manure is also applicable to waste water processing, they will have an interest in the development of this technology as well. However, besides possibly using or purchasing technology/systems from manure thin fraction technology providers (and vice versa) with possible collaboration, they have a limited interest. A noteworthy point: one participant originates in this industry and then expanded to manure processing, making systems for both industries [I4].

viii. Consumers and general public: The consumers and general public also do not have an immediate direct interaction with the manure processing niche, but they do have an interest in the environmental, health and safety impact. One could even see the (international) pressure such as that by Greenpeace and the World Wide Funds for lower emissions as a public concern (NOS, 2021). Consumption of meat products will have an effect on livestock production and thus also the quantity of manure processing, meaning consumer habits has an indirect effect. However, it was also noted by participants that the public can put pressure on local governments to in turn take action for or against the industry [I5, I6]. For example odour nuisance of installations is a direct impact to society, because processing manure may release manure-related odours in the environment which are unpleasant for the public (Verdoes et al., 2021).

ix. Banks and financing institutions: These have the main focus of generating profits from loans and interests and thus indirectly cooperate with farms and installations. However, as one participant pointed out, they are generally reluctant to work with the manure processing industry due to the low profits and high risks involved, meaning in several cases prospective manure processing firms have to find their funding elsewhere [I2].

What is useful to point out is that all these stakeholders are of the Netherlands. The Netherlands is one of the largest players in the manure processing and recycling niche, however, other countries will also have similar stakeholders with similar views, yet the execution and desires may be slightly different [I4]. These will not explicitly be covered in this paper. Nonetheless, it is good to keep in mind that there is occasionally international cooperation between firms, governments (EU laws) and universities of different countries (especially Belgium and Germany).

Stakeholder map:
To briefly summarise the above mentioned points, a stakeholder map was created to show the different actors and how they are linked. This can be seen in figure 4.4.

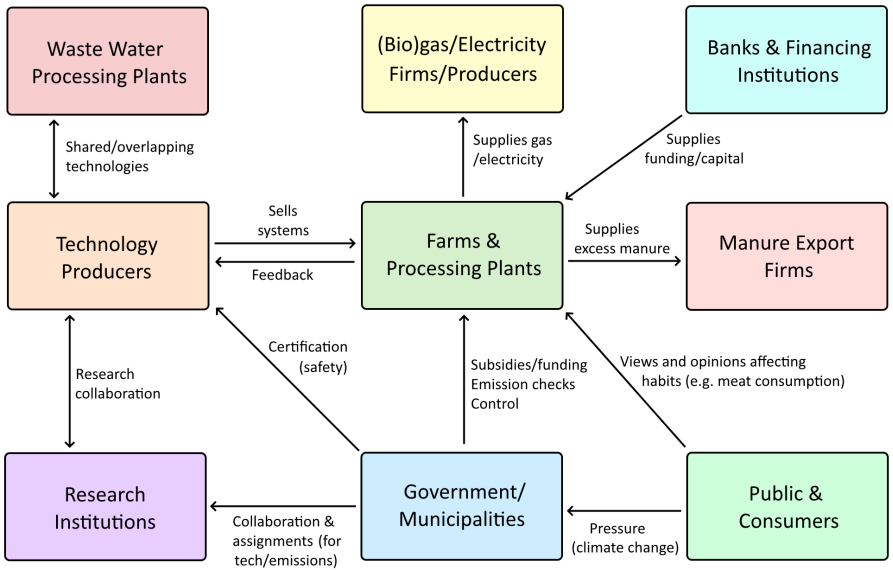

Figure 4.4: Overview of the stakeholders related to and affecting the niche and their connection

Please note that this stakeholder map contains more than just the niche actors. It contains essentially all major stakeholders of the socio-technical regime that have a direct influence on the niche in some way. Another interesting and important thing to note in figure 4.4 is that the subsidies applies for the farmers and processing plants, but not for the manure processing technology producers. This is because the farmer and processing plants are actually the ones reducing emissions in the end and they are the ones who have to apply for subsidies.

4.2.2 Technological fit

This part is on technical aspects outside of the niche and how it can have an effect on the niche. For the manure processing niche this mostly is with regard to their targeted industry: farmers and manure processing firms.

Farming has been around for hundreds of years and modern farming practices and machinery have made it more efficient in the last century. However, besides these technological advancements, agriculture has remained relatively consistent and is not affected by all that much. Farmland is limited in the Netherlands (being a small country) and already largely utilized where possible. Furthermore, resources for agriculture have also remained fairly consistent with artificial fertilizers brought in from outside countries as well as produced within the country [I1].

However, one factor that does have an effect on the cost of excess manure disposal (which is what arguably initiated the manure processing firms to exist in the first place) is transportation costs [I1, I2]. The key roadway network and manure transportation methods (predominantly trucks) have been around for decades and have remained relatively stable. However, the slow phasing out of fossil fuels (including increasing fossil fuel prices already happening today [I1]) as well as uncertain alternative fuels for transportation means that costs may fluctuate and/or increase significantly (Energy Transitions Commission, 2017). Thus, if the transportation infrastructure becomes more expensive, the cost of manure disposal (especially export to other countries) increases, which in turn will make manure processing technologies more viable.

Two participants even noted that infrastructure can be a limiting factor. Many manure processing firms start out as regular farms on regular narrow farm roads, which means that at one point the small roads are at their capacity with truckloads of manure coming in and out and logistics gets difficult [I2, I5]. To put it in perspective, if you have a very large installation (300,000 m^3/yr+) then you may have 40 trucks coming and going every day, which can be a nuisance to the locals who are cycling or walking on the same roads and soon the municipality may be against you [I5]. One of the large participants even has their trucks drive special routes to reduce the nuisance from trucks [I7].

One could argue it is possible to move to an industrial-terrain, but this is not a good idea [I5]. Firstly, you need a "category 5" terrain for heavy industry, of which there are few in the Netherlands. Secondly, although easily accessible, they are usually by cities, meaning more traffic jams and related higher transportation costs. Thirdly, those terrains often have manufacturing and storage of life-goods and medicine, where manure is not easily accepted. Fourthly, the land price is much higher and can easily be € 1000 per day or € 2 per m^3 manure. Thus, overall a rural location fits best with good enough infrastructure, a calm environment and cheaper prices [I5]. It also helps if the

land is already written off (i.e. you own it fully) as it also saves significantly on costs, something which is not the case when choosing a greenfield location [I5].

Related to the land, certain forms of manure processing takes up a large amount of space, such as the fermentation silos for biogas production, meaning that one can only expand so much on a given plot of land [I1].

4.2.3 Rules, laws and regulations

As mentioned during the methodology, only regulative rules will be investigated as the other forms of rules (normative and cognitive) would be difficult to investigate and likely has a significantly smaller effect. Within regulative rules, European rules having an effect on the Dutch market, as well as Dutch rules are investigated. Similarly, the investigated rules are those that have an effect on agriculture relevant to manure processing.

i. Agriculture laws:
Regarding agricultural laws that have an effect on the manure processing niche, there is one very important rule: Directive 91/676/EEC of 12 December 1991, concerning the protection of waters against pollution caused by nitrates from agricultural sources. This rule states that farmers are only allowed to use up to 385 kg of pure nitrogen per hectare per year, where only 170 kg can originate from manure (European Union, 1992). In cases of derogation (exceptions for certain circumstances) this may increase up to 245 kg from manure (Oenema, 2020). Surprisingly, this rule has not been updated since being introduced in 1992 and navigating the current rules on the Dutch government website directly leads to the 1992 directive (Rijksdienst voor Ondernemend Nederland, 2021a).

Also, due to the large amounts of livestock in the Netherlands on a relatively small area of land, there has almost always been more manure produced than legally allowed on the land, especially with regard to phosphate, whereas other EU countries have a (phosphate) deficit. This led to the 2013 'mestverwerkingsplicht' law (Stb. 2013, 576/577), which translates to 'mandatory manure processing obligation' where up to 30% of all of a farm's manure needs to be processed and exported to other EU countries depending on the region as of 2013 (Ministry of Agriculture, Nature and Food Quality, 2013) and since 2017 even up to 59% (Rijksdienst voor Ondernemend Nederland, 2022). This law also subsequently led to the large number of manure transportation and export firms identified in the literature review (over 1100 firms). In other words, one could make the argument that these two main laws have practically formed the entire manure processing niche in the Netherlands.

There are further rules for manure with respect to transportation, how manure should be deposited on farmland and during what times of the year (to reduce emissions and increase crop output) and hygiene, but these rules do not have a significant positive or negative effect on the manure processing niche (Rijksdienst voor Ondernemend Nederland, 2021c). The only rule that might have a small effect is that firms that process, compost or ferment (for biogas) manure need to be officially registered, which may pose a small regulative barrier to new manure processing entrants (Rijksdienst voor Ondernemend Nederland, 2021c). Besides that, no real rules for manure processing have been found besides generic rules that apply to all technologies (e.g. safety, certification).

Also, one participant noted that the government has a vision for the future to make manure 'ground-bound' (meaning that a farm needs to have enough ground to use all of their manure, or it should have some ground somewhere close by assigned to be used for their manure and not others) or they would have to process 100% of their manure [I8]. Something similar is already in place for cow farms, as currently only a certain amount of cows are allowed per area farmland, but this is not the case for pigs, which combined created an excess of manure that has to be exported as per the 2013 'mestverwerkingsplicht' law [I8]. However (as discussed later on) there may not be excess manure in the future anymore, but the export requirements still exist, so the rules need to be updated to resolve this imbalance [I6, I8]. In fact, the rules for manure are in general somewhat vague, since although the general idea is consistent (to reduce emissions and make agriculture more sustainable), the goals are not executed clearly, leaving firms and farmers not knowing where to work towards (e.g. exporting-focused technology or processing-focused technology?) [I7, I8]. This also means that a farmer may not know if they will exist 3 years from now for example [I7].

Another participant elaborates, stating that the whole branch by politics needs to be clearer in what should happen, stating that one year the government wants to reduce livestock, but the next year the governments says livestock can stay but the manure surplus should be gone [I7]. Similarly, that participant noted that the mandatory export percentage of up to 59% is also unclear, as it is not known if this for the whole area as an average or on a per-firm basis. With these examples, it was noted that the long term vision of the government is missing, yet everyone knows there's a manure surplus and something needs to be done [I7].

Furthermore, at the moment of writing of this thesis, any manure that is processed still just counts as manure and should follow the 1992 directive. However, this is planned to change soon with the upcoming RENURE legislation.

ii. RENURE:
Also known as REcovered NUtrients from manuRE, is a legislation that will come into effect in the coming years to work towards a circular economy (Ministry of Agriculture, Nature and Food Quality, 2021). With this legislation, manure that is processed into a nitrogen fertilizer (including mineral concentrates) can be used on farmland without counting towards the manure fertilization limit of 170 kg N/ha/yr (Huygens et al., 2020). This can be seen as a logical step and is good for the manure processing niche since fertilizers complying with RENURE will have similarly low emissions compared to artificial fertilizers without having negative emissions impacts upstream since many artificial fertilizers originate from mines in third world countries (Huygens et al., 2020). Figure 4.5 shows the concept and it can be argued that RENURE will increase the motivation of the manure processing niche to make and use more advanced manure processing technologies.

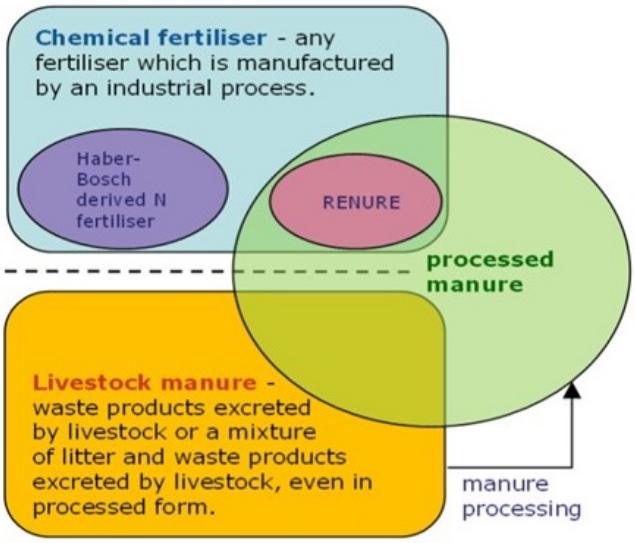

Figure 4.5: Overview of the RENURE classification (Huygens et al., 2020)

Several participant see such a law as essential [I3, I5], since currently the law makes no distinction between processed and unprocessed manure, which is limiting the processing industry: the old laws are made on old technology (e.g. separation and hygienisation for export) and not ready for new technology (e.g. fermentation and osmosis for value recovery) - this needs to change [I3, I6, I8], especially since currently the system favours cheaper firms that just export manure rather than actually process it [I6]. Other participants agree with this, stating that newer technologies and innovations have created a huge decoupling between the rules and the intentions [I4], and that it does not align with the original intention of processing manure to export excess phosphate [I5, I6, I8]. In fact, two participants noted that RENURE will change the output of processing systems from (legally speaking) a waste stream in the manure market to a product in the fertilizer market [I5, I7]. Thus, the outputs need to be officially recognized as an end product, which should also help players in the industry with selling their manure-based fertilizers [I7]. Also, with this it will also allow for officially recognized (and perhaps even standardised) processes to exist in the future, which should help the industry [I5] and would make the market more well-balanced [I6].

However, some participants are sceptical of when RENURE will come. The proposal for this legislation has been around since 2009 when the first pilot tests were happening and originally it was supposed to be implemented 3 years later [I2]. However, after several further pilot programs, RENURE kept being pushed back and it is unsure if the implementation in 2022 will actually happen or if it will be delayed yet again [I2]. One participant even has had a technology ready for RENURE for 10 years and there were always interested parties, but a sale was almost never made due to the rules still not allowing its products to be used as artificial fertilizer [I4].

Nonetheless, all participants do unanimously agree that it will help the processing industry and increase available options, however, one participant noted that there are talks to link RENURE to the derogation availability, which is renewed for a farmer roughly every 3 years [I4]. This may not

be a great idea, because it would then still mean that getting an installation is an insecure option, in case the derogation is not given for the next time period. Because of this, participant 4 is slowly starting to doubt if RENURE will help the industry in the long run in the way it was promised to them, but he is still hopeful for the best.

iii. Subsidies:
Besides rules there are multiple subsidies for farmers and systems related to manure. The first of these is the 'Sustainable Agriculture Conversion Program' which is an initiative in cooperation with 'Nationaal Groenfonds' where loans up to €400,000 per farm are available at a very low (but unspecified) rate (Nationaal Groenfonds, 2021). Another important subsidy is the 'subsidy for innovative solutions to make stables more sustainable' (officially known as Sbv: subsidie voor innovatieve oplossingen om stallen te verduurzamen: WJZ 20022360-27006) where 40-60% of the upfront cost is paid for fully by the government and sometimes also up to 40% of the operating costs (Koekkoek, 2021; Ministry of Agriculture, Nature and Food Quality, 2020) [I3]. This subsidy is meant for novel (and in several cases unproven) technologies and is determined on a case-by-case basis. The government also made a subsidy budget available of € 52.4 million as of December 2021 for "investing in the green economic recovery of agriculture" which includes manure processing and has a multitude of requirements (Rijksdienst voor Ondernemend Nederland, 2021d)[I3]. There is even a subsidy programme to buy out firms with livestock in or near Natura2000 areas in order to reduce emissions, known as the 'Landelijke beëindigingsregeling veehouderijlocaties' or Lbv (Koekkoek, 2021).

As of November 2021, the major Dutch political parties have also set aside € 20-30 billion to reduce nitrogen emissions as a transition plan in the Netherlands, focusing on agriculture and suggesting it to be used for buying out farms (Wintermans, 2021). However, one participant noted that it would be better to keep the livestock and use manure processing installations to reduce emissions, stating that roughly 20% of those funds would fully cover the machines for the top 4000 emitters in the agricultural sector [I3]. However, the laws should be made attractive enough so that farmers actually want to acquire the technology and it appears the governmental regulations are not always properly aligned to achieve this.

Other participants have a similar point of view: the government is quick to come with these drastic solutions, however, solutions such as halving the number of livestock will kill off the manure processing industry or at least bankrupt many firms [I4, I8]. This is because it will eliminate the manure surplus (manure production decreases, but crop production and manure usage limits stays the same, meaning the new quantity of manure is sufficient for all needs in the Netherlands), causing the manure disposal fee to drop, probably significantly [I4, I8] or at least reducing the quantity of excess manure to be processed, meaning installations may not run at full capacity [I6]. In either case, this makes manure processing unprofitable [I4] and although higher expected mineral prices will help alleviate some of these losses, it will not make up for the lower manure price [I8]. With this in mind, the future may not look bright for those focused purely on only manure exportation [I6, I8]. Moreover, international markets often look at the Netherlands for manure processing technology and innovation and if the manure processing industry stops and livestock is reduced, international players may eventually surpass the Netherlands in terms of innovation [I4].

One participant even noted that they do not make use of any subsidies [I5]. This is because in practice it can sometimes be very difficult to get the subsidies working effectively for you on the work-floor. When applying and receiving subsidies, often there are multiple parties involved, such as universities monitoring and reporting everything and often expensive consultancy firms, which together can consume most of the subsidy money [I5]. In addition, because there are multiple parties involved and everyone is trying to steer you away to their own opinion/view, you sometimes end up further away from solving the problem than what you started with [I5].

Furthermore, there are also proposed subsidy plans that are not yet in effect. For example, the Dutch chamber of commerce (KvK) said that there will be a multi-year subsidy scheme for high-value manure processing and fertilizer replacement (i.e. for the more advanced manure processing technologies), although it was not yet stated what these subsidies exactly will be yet. However, to go along with all these subsidies, it was also noted that there will be more strict emissions regulations within livestock stables between 2023 and 2025 (Koekkoek, 2021). For this there will be a transition period and again subsidies will be available for farmers to transition to cleaner solutions.

iv. Carbon capture:
Another regulation that can have an effect on manure processing is that of carbon certificates for Carbon Capture and Storage (CCS). Certain types of manure processing for the thick fraction (like biochar) can be stored in farm soil for extended periods of time, which can then be considered as a form of carbon capture. When officially registered and approved, this carbon capture can be exchanged for carbon credits, which can then be exchanged for money via the European Union Emissions Trading System (EU ETS) (Dutch Emission Authority, 2019). As of November 2021, the price for a carbon certificate is at its highest point in history, averaging around €60 per tonne CO_2 captured (EMBER, 2021). One source even mentioned that there is demand for carbon certificates (which drives up the price), but that supply is limited and that the Netherlands may not be best suited for carbon capture (Smit, 2021). None of the interviewed firms are currently making use of carbon credits, with only one interviewed firm saying they are looking into it for the possible future [I3].

v. Permits at the niche level:
Although permits are a regular part of any firm, it deserves its own subheading, because a significant number of participants agreed that the current permit system at the niche level is a huge hurdle, often being a difficult and lengthy process [I1, I2, I6, I7, I8]. This problem is not just for initially applying, but also for updating a permit related to manure processing. More specifically, for practically every change/update to a manure processing plant, whether it be changing the quantity of manure you wish to process, changing the location or business entity to process manure, or changing/updating the technology/system to process manure with, the whole permit application process needs to be repeated.

This is a problem, since there is a general negative attitude of social organizations and governments against manure processing, leading to permits not being granted or delayed for long periods of time, with multiple years not being uncommon [I1]. One participant even noted that the very tight (and outdated) definition of what entails manure processing makes getting permits difficult and does not leave (as much) room for newer technologies or innovations [I6]. This also prevented that participant from partaking in some new initiatives as acquiring the permits was very difficult [I6].

Also, local municipalities are not always cooperative with fears of odour nuisance and potential fraud, further delaying the process. As one participant notes, you need to work on your public network and try to get them on your side, because they are eventually the ones approving the permit [I8]. After all, as another participant puts it: "Essentially it's like windmills. Everyone is OK with it coming, but nobody wants to have it in their backyard" [I7].

This can be a huge problem, because if you need to update the permit, it sometimes takes very long. One participant noted that they were looking into processing other types of manure to further fill up their capacity, but this would require a new different permit and the lengthy and difficult process is putting them off [I7]. By the time a permit for a new technology is approved and built, many years could have passed and the new installation could even be outdated already [I1]. Similarly, if you want to process more manure of other close by farms or different types of manure, it is not allowed without a permit update. This has gone to the extent where some farms are practically forced to break the law. One participant (who shall remain unnamed) admitted that he is illegally processing (part of) his manure at another installation 300 m away, which is technically not allowed due to both locations having separate permits, even though practically speaking the manure is still processed to a better lower-emission substance. One participant gave an example of that in one area 13 permits were granted in the span of a couple of months, whereas another area has a firm that has been fighting for 12 years to obtain a permit, which shows the importance of having the public and local municipalities on your side [I8].

Fortunately, some participants are noting that they are seeing an improvement in awareness and dedication by the government and the government even noted that they are going to tackle this problem, but the progress is still slow [I1, I2].

4.3 Summary of the MLP perspective

In this chapter, the outside forces and factors acting on and affecting the niche were investigated. For the macroeconomic landscape level, climate change and awareness did have some effect, but nowhere near as much as the 2019 nitrogen crisis. The nitrogen crisis was caused by the Netherlands not meeting EU laws, halting construction projects and putting pressure on the agricultural industry to reduce their emissions. Meanwhile, other macroeconomic factors such as the 2008 economic crisis and Covid-19 did not have a significant effect for most, stating that having a bad year occasionally is not uncommon, but the increasing natural resource scarcity does have an effect, helping out the niche by allowing the players in the niche to charge more for their end products.

For the socio-technical regime, a stakeholder map was made, showing that there are many stakeholders with the most interaction occurring between the manure processors and the equipment producers, since they often work together. In terms of technological fit, an ideal size was found to process manure in a 15-20 km radius for the best profitability. Laws and regulations were also investigated, which had a significant impact. On the one hand, major laws haven't changed in a long time and the upcoming RENURE law as well as government funding and subsidies should help the industry, but on the other hand, a difficult and lengthy permit process and uncertain future due to constantly changing views and proposed laws is hindering the industry. Meanwhile, the niche level of the MLP is investigated separately using SNM, which is handled next.

5 The SNM Perspective

5.1 Shielding

This is split up into passive shielding, where the innovation can develop and grow away from any disadvantageous selection pressures, and active shielding, where the selection pressures are present, but the niche gets outside help in some form (such as laws, subsidies) to overcome those selection pressures.

One could make the argument that passive shielding is not strongly present in the Dutch market. The Netherlands is a very large player in agriculture and meat production with practically all the selection pressures present and well-established. Large incumbent firms and actors (mainly farms that do little to no manure processing) with economies of scale and focuses on cost reduction have been around for decades in practically all areas in the Netherlands where agriculture is possible, and networks between firms have long been established, so any new technology or firm will need to be able to compete with the current regime and all of its selection pressures.

As a counterpoint, one participant noted that there are very few competitors for him and it was easy to start out [I2]. This participant is a large systems producer who started almost 20 years ago and has since sold and operated around 20 systems in the Netherlands. He mentioned that he really only has one main competitor in the industry and that the market is already slowly reaching the point of saturation as there is not enough demand for processing systems for a huge variety of firms to exist [I2]. Similarly, another participant noted that the Dutch market is too small and thus is looking internationally [I4]. However, this in fact supports that there is little passive shielding, since these participants are now the large incumbent firms. Participant 2 also noted that there are many newcomers with supposedly new technologies but that they often fail, which again shows that the selection pressures are in full force. Additionally, almost every farm that processes manure directly competes with each other to sell their mineral concentrate and thick fraction (e.g. compost) outputs, meaning a newcomer directly has to compete with their market prices too [I2].

Instead, most of the shielding is in the form of active shielding. If it were not for the regulations and interventions by the government regarding not only limited nitrogen usage and nitrogen emissions, but also the aid for innovators in the niche, the manure processing niche would likely not exist or grow to the same degree it does now. As mentioned in section 4, the directive introduced in 1992 limited the usage of manure on land, leading to a surplus of manure in the country that has to be taken away (often out of the country) and resulted in a negative manure price. This regulation and resulting negative manure price already meant that simple manure processing could be a viable alternative to reduce costs for a farmer. Subsequent introduction of subsidies and cheap loans to help innovative 'green' solutions further shielded the niche and in the not very distant future there will most likely be new regulations introduced to further shield the niche and put pressure on the current regime (of unprocessed manure). As pointed out by Smith and Raven (2012), changing preferences caused by awareness of the nitrogen problem further puts pressure on the incumbent regime.

However, as noted before, the lengthy and sometimes unsuccessful permit process is somewhat hindering the active shielding of the government, not to mention that the uncertainty surrounding what the shielding will be in the future and how it will change is putting some farmers and processors off from taking full advantage of the shielding [I1, I2].

5.2 Nurturing

Nurturing consists of 3 parts, which are each discussed individually next.

5.2.1 Voicing and shaping of expectations

In this part only the internal expectations from within the niche will be considered. This can be further split up into exogenous expectations, which originate from landscape and regime factors, and endogenous expectations, which originate from the learning experiences of the (interviewed) firms themselves.

Exogenous:
There are quite a few expectations of where the manure industry will go to in the future, especially with regard to the market and the government.

One of the participants noted that the government likes the idea of each farm processing their own manure, however, in such a case every farmer needs to have a tremendous amount of knowledge [I1]. Besides knowledge of their animals, well-being, nutrition, marketing, production, labour conditions, PR and communications, they are suddenly also expected to have practically half of a technical degree for all the extra technologies and systems that is added on their farms to process manure. Participant 1 is sceptical that this is actually feasible and does not expect this to happen.

Related to this, a separate installation on each farm is not expected to be successful [I1]. Modern farms have few employees and they cannot be everywhere at the same time, meaning that (from experience of participant 1) sometimes a farmer focuses so much on manure processing to save €50,000 that they leave €100,000 uncaught with their main occupation because they simply did not have the time to give it more attention. Also, it is expected that installations will stay regional, typically within a 10-15 km radius, as then installations can be large enough to be viable, but close enough to limit excessive transportation costs [I1, I2, I5, I6]. One participant noted a further distinction, stating that cow manure processing will stay regional and at a relatively small scale (although cooperations are still useful), whereas poultry livestock (which has a large international market and already starts out much dryer) is at a large scale, and pig-manure is processed at possibly an in-between scale, since it is much more viable in combination with biogas, which requires a certain minimum size [I8]. This is backed up by participant 7, as they are the only interviewed processor that processes pig manure in combination with biogas and they take in manure from areas of the immediately surrounding provinces (very roughly speaking a radius of around 40 km), although they note that agriculture is less intense in their area.

Furthermore, from a more global perspective, mineral prices are expected to increase, which should make manure processing, especially into mineral concentrates, more viable [I1, I3, I8], but also, due to the higher future cost of minerals, precision farming with more precise mineral application to reduce wastage will likely be more predominant in the future [I1].

Also, related to the subsidies, they are expected to remain in substantial quantities for the foreseeable future [I3]. Since emissions are such a large problem for the Netherlands and there are no easy solutions, the subsidies will need to remain in order to solve the problem in some way. Because of these expectations, firms rely on subsidies to cover enough of the cost to survive [I3]. However, as mentioned during the last chapter (on subsidies), if the livestock market shrinks, it is expected to really hamper the manure processing industry due to a multitude of reasons [I4, I6, I8]. In such a case the help and subsidies from the government may not be sufficient to allow much more significant implementation and innovation in the manure processing industry to occur. As pointed out by participant 8, the manure market is currently supply orientated with a negative manure price, acting as waste disposal firms, but if they wish to survive, they need to orientate manure as a valuable product instead [I8]. Meanwhile, participant 7 is relying on the manure market to remain the same, expecting there to be enough manure in their region and with costs and revenues for their installation being calculated at full capacity, although they do agree with orientating it as a valuable product and not a waste [I7].

This leads to perhaps one of the largest expectations: that the industry could go in any direction still [I5, I7] and is heavily dependent on the rules and regulations that are implemented by the government [I1, I4, I5, I6]. It could be that regulations stay roughly the same, meaning that those that currently have it under control will continue on in the future given they have a good installation [I2, I5], or perhaps the livestock may shrink, reducing the necessity of manure processing, which shrinks the industry [I4, I5, I6, I8]. It could perhaps even be that new laws are implemented that would require less manure to be used on land, forcing more manure to be processed to more valuable products, increasing the industry and perhaps even decoupling the quantity of livestock from the manure surplus [I5, I8]. Those that were interviewed that did have a set/fixed idea of where the industry would go did not unanimously agree on the direction either, which shows the uncertainty that the future may hold. One participant even noted that if the government was clear as to what happens the next 10 years, then entrepreneurs can go in on it and it would be better for the whole market [I7]. After all, the market is there and the willingness by farmers and entrepreneurs too, meaning there is a lot of potential [I7].

Endogenous:
Over the years, practical experience has played a large role for several firms on shaping their expectations. Most have noted that there were some hurdles getting the technology to work in the beginning and/or to get the available finances in order [I2, I3, I6, I7], but these are regular things to be expected [I2]. From this trial and error though, a lot was learned, which formed expectations. For example, technologies that use a lot of energy can quickly become unprofitable [I1] and technologies that have a lot of outputs or products can be disadvantageous, because not only do you need to find more buyers to reliably pick up each output, the quantities are smaller, making it more difficult to sell [I1]. This is somewhat experienced by participant 7 as they are having difficulties selling their potassium (K_2O) fertilizer [I7]. Then again, another participant noted that having different outputs, especially if they are separate minerals, allows the farmer to delicately select the minerals they need for their land, which is better for their crops [I3, I8]. Thus, concerning the optimal number of outputs there is some discrepancy between firms, but both directions have justifiable reasons.

Similarly, with the combined experience, it was noted that many methods and technologies have already been tried out and that it is best to no 're-invent the wheel'. In fact, although there is hope for a radical new technology, current and future improvements are likely to be incremental and optimization-based (but generally not big) rather than completely different new technologies, but only time will tell [I2]. Another participant agrees stating that new techniques and technologies are needed to make big differences, especially when it comes to lowering the back-end costs like that of the thick fraction [I6]. One participant that does have a relatively new technology (evaporation to separate the mineral concentrate) said they expect it to be trial and error at the start to get it working well [I7], meaning that even if a new technology comes, a learning curve is expected.

Another useful thing one participant pointed out is that the combination of processing manure with extracting biogas (energy) is a good way to go and that firms that do not combine multiple processes to extract the most of the stream are likely to disappear sooner or later [I4, I8]. Notably, unlike cows, pigs have only one stomach, meaning that most of the methane is still in the manure. This means that pig-manure can produce around 70 m^3 of biogas per tonne manure (versus 20 m^3 for cow manure), which can eventually result in € 20 per tonne of manure of income; the difference between making a big loss and being profitable [I8]. Add the revenue of thin fraction processing on top of that and the profitability increases more. However, a discrepancy in this is that firm 7 is planning on producing 5,000,000 m^3 biogas from 250,000 t pig manure per year, which comes to 20 m^3/t; much lower than the 70 m^3/t mentioned by participant 8, although firm 7 still has to construct their setup and the fact that they have a mono-fermenter (only manure and nothing else is fermented) may have something to do with it. In any case, efficiency improvements for biogas production are expected in the future, which in combination with natural gas supplies expecting to be decreasing in the future as well as lower emissions for biogas means that biogas can be a very suitable use for manure [I8].

5.2.2 Formation of networks

This can be split up into two parts: the composition of the network (who is in the network) and alignment (how well do they cooperate and do they have the same views and goals). Both will be discussed below.

Composition:
Every firm has their own networks, but generally speaking there is some correlation. Many firms cooperate with a variety of actors ranging from regular farmers to equipment producers, municipalities and research organisations, but they are mainly people with the same view and who have the same ideas of what sort of end products they would like, certification and quality of the process/outcome [I1]. This generally results in an informal clustering of actors involved who share their ideas and expertise. One participant noted this as a "unique world", since there are no specific interest groups [I1], no clear indication of where to find the 'clubs' or where to go, not even a website, and yet everyone does sort of know each other and know where to look [I2].

This can be a problem for newcomers who are not yet within these groups and who want to start processing manure as they have no good guidance on how to start. One participant noted that it is sad that so much time and money is wasted on installations that are already proven to not work, which could have been prevented if they only did some research beforehand or had gotten guidance

[I2]. Another participant agrees, noting that in the past everyone was very much on their own, each trying to 're-invent the wheel' so to say, but learning from each other and sharing knowledge is very important to prevent unnecessary failure [I6]. With this in mind, openness is important for success, since the profit margins are too small and the risks are too high to blindly trust a new installation [I2, I6]. One participant noted that sometimes he is approached by firms in formal attire claiming they have *the* solution for manure and a business case on paper to back their claims, however, these firms may be dangerous as they have nothing to show in practice and you can easily go bankrupt in a few years if you decide to invest in those yet to be proven firms [I5]. One participant even noted that if he had to redo his business and also for future investments, he will look closely at a process that has proven itself already [I6]. Participant 7 agrees, noting there are very few people that can actually demonstrate that they can do it well, and as such they work with a supplier that also runs the system themselves, meaning that there is some assurance that the system works and they also benefit from their supplier further developing the system [I7].

Also useful to point out is that several of the installation producers use a lot of outsourcing of the construction and components, acting more as an overarching body to come up with innovation and the technical plan and let other people make the system [I3, I4]. Because of this, contractors are play a major part of their network composition.

Noteworthy, one participant said most research towards manure processing is given to Wageningen university, which they said is a shame, since other universities like TU Delft and Eindhoven also have the research capabilities and equipment, as well as arguably more expertise on certain related topics like membranes [I1]. Meanwhile, another participant noted that Wageningen university is a great source of expertise and that other countries look at them for agricultural research [I4]. Yet another 2 participants noted that there are projects at multiple universities and institutions, but that the collaboration between universities is sometimes far from ideal [I3] and that these projects are all separate with not much coherence [I8]. Related to this, participant 8 pointed out that there is a large fragmentation in the manure processing industry, where there are firms with good technology and projects, but no common unified agenda.

Alignment:
Regarding alignment, it is a bit of a mixed bag. Although the networks tend to have the same views, quite often the main actors who interact directly with the manure processing installation are or have a farm of some sort, meaning that even within a cooperation of a manure processing installation, eventually everyone is each other's competition [I1]. Some are satisfied with this and cooperate freely, whereas others do not like it and almost cooperate begrudgingly out of necessity [I1]. Similarly, although with a cooperation you have a lot of power coming from all of your members, you are limited in your agility as you need to treat everyone equally and fairly as it is essentially 'by the farmers, for the farmers'. Because of this, there is no negotiation in price under/between members and everyone gets the same price to keep it fair. However, that means if you need to pick up some (additional) manure to fill your capacity, you cannot simply say "I will pay € 1 less this time just to get this load in and make a deal" because that would go against the cooperation [I6]. Sometimes these things can make life difficult for a cooperation.

Interestingly, although there is competition, there is not a very strong rivalry between firms. For example, one participant noted that they wouldn't mind working together or cooperating with their

main competitor and thinks they are a genuine good, respected company, but they both have their own ideas of what is best and their own technologies that they think are better, so they don't cooperate [I2]. Another participant noted something very similar: they are open to conversation and collaboration wherever possible to identify opportunities, even if they may be competitors [I3]. One participant even goes so far to organise sessions to share technical data and look to share as much as possible, even with competitors [I6]. However, you still have to do a lot yourself, and with sharing it is sometimes difficult to make sense of it all, because every installation has different setups, layouts and people and so it is not always easy comparing the different installations with equal metrics [I6].

One area where there is possibly a misalignment is between the general agriculture (including manure processing) industry and the government and municipalities. There is a sort of hostility of the municipalities and governments against manure-related technologies, which the farming industry sees as unjustified [I1] and which creates political tension [I8]. For example, many years ago some local municipalities were strongly against recovering natural gas from manure, but now that the natural gas supplies in the Netherlands have stopped, it is suddenly seen as a great idea [I1]. The technology and methods for this have not changed significantly, yet misinformation, an overly relaxed view, and general disliking towards manure, especially in media, has unnecessarily hurt the innovation, development and adoption of manure processing technologies [I1]. As mentioned during the regulations section, the government wants to invest € 20-30 billion to reduce nitrogen emissions through buying out livestock farms, yet they do not consider what is arguably a better and cheaper solution for everyone involved: investing in the manure processing industry instead [I3]. However, as participant 8 noted out, the average civil servant is right in the middle of this 'fire' which makes it difficult to come up with a good solution which everyone is happy with [I8].

Participant 5 also noted that the execution is not always well-thought out. Although the vision of local politics is in the right direction (reducing emissions, helping innovation, providing subsidies), the people who execute the vision sometimes do not take responsibility, pushing work away from them, and would rather make a declaration on why it isn't their problem [I5]. This leads to lengthy processes, with multiple rounds of assessments, delaying even simple permit applications to multiple years [I5].

What also does not help with this is that there are quite a few 'horror' stories from the farmer's side. For example, the story of a farmer who got their permit for manure processing approved, then went through all the trouble of finding out, financing, installing and setting up a new manure processing installation, only to find out that the government made a mistake (after the installation was complete) and retracts the permit [I3]. This means that the € 2 million investment is lost, and which body will cover the cost/losses? No one. This unreliability in permits and uncertainty in (upcoming) laws from the government's side is causing a massive misalignment and putting farmers off from adopting the technology.

However, such horror stories are usually observed and experienced by the farmers and installations themselves. The system providers tend to have an easier time in this as they often do not have the risk of permits being retracted or destroyed. Also, one large system provider noted that they sometimes have 30 contractors working on a project and sometimes they are good, sometimes bad [I4]. However, problems can usually be settled in a professional manner and they are also insured,

which helps limit the effect of any problems they encounter [I4]. This shows that there is more alignment between the technology producers and farmers/installation purchasers than between the farmers and the government.

5.2.3 Iterative learning process

This part consists of 7 aspects (6 if business models are excluded, which is discussed separately), which are: Technical development and infrastructure, Industrial development and production, Development of user context, Societal and environmental impact, Government regulations and policies, and Resource potential. However, since some of these have overlap with previous sections and not every part got an explicit response, the interesting aspects will be discussed together.

One can even distinguish learning into practical/pragmatic learning and higher order/theoretical learning. However, most of the important learning experiences of the participants are practical, with trial and error, experience and seeing the success of what works for others being the main methods for learning [I1, I2, I5, I6]. Meanwhile, theoretical learning did play a role, as there are occasionally readings and events where participants sign up for to keep themselves up to date on the latest developments, but even then the practical learning is dominant. For example, participants noted that you should not believe everything you see on a presentation slide [I2] and that you should be sceptical on if it actually works [I1].

From these practical learning experiences, naturally, a lot has been learned. For example, as mentioned before, making an installation that actually works is very difficult and many firms do not succeed in this [I1, I2, I5]. Similarly, firm 5 believes that unless you are involved with the creation of the system from the start, they rarely ever work. At the end of the day, you really got to know your requirements and what you're doing and then you make your system for that [I5]. With this in mind, although it may be expensive, cutting corners can lead to a whole installation being useless or breaking prematurely, and similarly, seeking advice and getting properly informed beforehand can prevent these bad decisions [I2, I6]. As one participant noted "You have to listen very carefully to the people who have a lot of experience and say, manure is difficult stuff. Keep that in mind. They say that out of the best of intentions, because it is a weird substance and it's more difficult than you think" [I3] or as another participant noted "It's not just a cookie factory that you turn on in the morning and turn off in the evening. No, there is always something happening. You have to keep in mind you will hit hurdles sometimes" [I6].

With this in mind, the industry is still developing dynamically, with many players looking at what is the best way to process manure and ferment [I7]. One participant even mentioned there is still a lot more potential left and they want to capture that potential and are looking for synergy in future solutions [I7]. For example, there are a few (new) firms that try to create systems that do not use any flocculants (e.g. polymers and iron sulphates) to separate manure into a thick and thin fraction [I5]. However, firm 5 says that anyone who claims to not need flocculants has never worked with manure and that all successful manure processing firms use flocculants. From this, a golden rule is that to get a good end product you have to make sure it is well-separated at the start. You cannot correct a watery thick fraction or a contaminated thin fraction at a later point [I5]. Similarly, filters should not replace flocculants, because much like a fuel filter in a car, they are an

extra safety measure in case small quantities of manure get through the primary separation step(s), but will clog quickly if fed a dirty input [I5]. However, it is understandable that firms are looking at removing flocculants. Besides these additives having an environmental impact, flocculants can account for up to 30% of your processing costs [I5].

Another golden rule brought up by firm 5 is "massa is kassa" or directly translated "mass is cash" with which he means that you ideally want to run 24/7 and run big volumes. In his opinion, if you are in a manure surplus area, an installation of 100,000 to 200,000 m^3 per year is ideal and allows you to process most excess manure in a 15 km radius region. However, the volume should also not be too big. As soon as you reach a size of 300,000 to 400,000 m^3 per year, infrastructure can start to become a problem (as discussed in the 'technological fit' section) and you will also need to take in manure from outside a 15 km radius, which is not only more costly, but will result in higher emissions too [I5]. Meanwhile, participant 8 noted that 500-1000 cows is ideal for a small installation (which at 80 L manure per day per cow equals 14,600-29,200 m^3 per year), which is significantly smaller than what firm 5 noted [I8]. Here it was noted that with a project from Friesland Campina ('Jump start'), at least 200 cows are needed, or 500 if biogas is included, to make it worth it [I8]. However, it should be noted that this low end number is likely including subsidies and to make it cheaper compared to paying the regular disposal fee, whereas firm 5 is focused on actually making profits without having any subsidies (to be explained in the business model section), which explains the larger size.

Next, a useful practical learning experience is that commitment is very important. A contract between manure suppliers and those who buy the process products (e.g. mineral concentrates) allows for stability and predictability, which is crucial for a constant operation and in the long run allows for peace of mind [I1, I6, I7]. Sometimes annual prices for manure and the mineral concentrates might be too high, sometimes too low, but without commitment, the farm might sell manure to another cheaper installation depending on the specific weekly prices [I1]. However, sometimes getting (long-term) contracts signed and sorted can be difficult, as farmers do not always have the vision to look in the long run and can be conservative, especially since pig farmers are generally not making much of a profit at the moment [I7].

Along similar lines, some processors open a big installation in the hope to get manure, but then eventually fail as they do not have a steady input of manure [I1]. Also, sometimes to further ensure commitment, the manure processing installations are partially owned by multiple parties, such as the installation systems producers, farmers and even contractors that work on the farm [I1, I2, I6]. This ensures that everyone is dedicated to making it work [I1, I6] and one participant even mentioned that this continuity and consistency, following a set schedule, is the best way for running a business [I7]. This is in contrast to firm 5 though, who does not rely on commitment or collaboration with other firms to have their manure processed. Instead, they offer a cost-effective manure price and a reliable service to keep customers coming every time [I5]. Perhaps then the learning advice varies per firm and location, but there is agreement that if you do not go for a contract, you need to have relatively cheap prices and capacity to accept manure coming your way.

On a somewhat related point to stability, one participant noted they wanted to be completely self-sufficient, working without government interference and trying to be less reliant on rules and regulations [I6]. They learned that the future of the industry and manure prices is uncertain, so

they want to extract as much value as possible and lower costs to ensure that even if the future is non-ideal, they will be able to survive. Especially since they are a cooperation which is 'for the farmers/members' it should give peace of mind and they hope to reduce the fee for their members in the future [I6].

Furthermore, oftentimes farmers or related firms are the ones setting up an installation, which are frequently also family run businesses, and one participant noted that unlike (for example) the waste water management industry where everyone involved is a higher-educated professional, most users of manure processing technologies are not professionals [I4]. This was also noted by participant 7, as they say it does not always align with their quality requirements, because farmers tend to have a different level of safety, refinement and maintainability, which can be difficult at times [I7]. This also means that with all the complex manure accounting, laws, forms and codes, it is easy to make an administrative mistake and these sometimes come in the news, harming the image of the industry [I4, I7]. One participant even noted that there is a certain view of manure processing/fermentation and that often the bad parts get covered in media, which does not help with the public's view [I7]. However as another participant (who wishes to remain un-referenced for this) says; there are certainly also a few real criminals in the industry and it is better to not do business with them as they can also taint your name by association. 2 other participants agree, noting that some parts of the industry have a fraudulent 'taste' to it, so it is best to not end up on a list of suspicion [I8] and if there is a firm who you suspect of doing something dubious, it is best to avoid collaborating with them to prevent tainting your reputation by association [I6].

Also related to the point that users in the manure processing industry are not always professionals, big firms like in the vegetable processing industry look at the cheapest total cost of ownership (TCO), which should determine the purchase of an installation, however, manure processing firms often go for the lowest CAPEX installation instead [I4]. This could either be due to some manure processing firms not fully grasping the concept of a cheaper TCO despite higher initial cost, or it could actively be because of the risks involved in the industry that if it goes wrong (e.g. permit retracted) that they lose less capital. Either way, it is still possible to set up the cost structure differently or to offer lease options, so that it is still possible to reduce the (perceived) CAPEX, while still having a cheaper TCO [I4].

Related to this, manure processing equipment firms don't always know much about agriculture itself and vice versa, meaning that the final products may not always be suited to what the farmer or land desires or occasionally stupid actions are taken such as separated manure being combined together again in a large storage tank, defeating the purpose of separation/processing [I8].

Finally, one participant who entered the market coming from a non-agricultural background said one of the biggest things he learned was the frustration farmers deal with [I3]. Most 'real' farmers just want to milk their cows and grow crops and do it compliantly [I2, I3] and do not want to be involved in any potential 'horror stories' as mentioned before. There is a manure problem to solve, but at the same time a farmer also needs to be able to survive (financially) which is difficult with the current market and you need a lot of resilience to carry on where others would have stopped long ago [I7].

5.3 Empowerment

For empowerment, niche innovators can either 'fit and conform' where the niche becomes competitive without altering the regime's selection pressures, or they can 'stretch and transform', where the "rules of the game" are changed, aiding diffusion and allowing the niche to be competitive.

The manure processing niche can be seen as a largely stretch and transform type of empowerment. As mentioned during the shielding subsection, laws and regulations towards lower emissions largely caused the "rules of the game" to be changed in favour of the manure processing niche, allowing it to be competitive. However, each time the regime's selection environment was altered, it was done gradually and with sufficient time in between (even going so far as to offer transition periods for upcoming regulations), which allowed for the new technologies and methods to adapt and conform with the incumbent agricultural firms. This also means that every time a regulation change is made, the now-conforming manure processing niche firm is (hopefully) well-established and can take better advantage of the upcoming regulation changes and any firm that does not conform anymore, will have had some time to exit the market gradually. However, as argued by some participants, this transition is sometimes too slow and certain law changes such as RENURE should have happened long ago, since now the industry is essentially just waiting for approval of such laws so that they can finally continue to develop and grow [I1, I2, I4, I5]. Combining this with an uncertain future and what you get is that there is no guarantee that a window of opportunity might come.

Nevertheless, this slower transition is logical from the government's perspective as the agricultural industry is very large and important in the Netherlands and rapid badly planned changes could end catastrophically. Thus, one can argue that there is also a little bit of 'fit and conform' empowerment, but at the end of the day, the manure processing niche would have likely never taken off if it weren't for the law and regulation changes that initiated the stretch and transform empowerment.

5.4 Summary of the SNM perspective

This chapter looked at how the players in the industry are taking on the challenges they face, using the 3 main aspects from SNM. For the first aspect, shielding, it was deduced that active shielding was more present than passive shielding due to laws and regulations forming the niche. Next, nurturing is split into 3 parts too. For exogenous expectations, mineral prices will likely increase, subsidies will remain, but the future is unpredictable, and for endogenous expectations, new firms will encounter hurdles at the start, should go for proven systems, and should look into combining biogas with mineral concentrates. For networks, the niche is a unique, but open world where there is no formal way of getting to know each other, yet everyone still mostly knows each other. Cooperation and sharing is needed to prevent repeating failures, but more importantly, there's a misalignment between the niche and government, since there is a disliking for the industry and there are some dubious people in the industry which isn't helping. For the learning process, practical learning was dominant with many expectations coming from this practical learning. It was learned that it takes time to perfect your process, that commitment in manure supply can be very useful, and that learning from each other is a key resource, since manure is not an easy substance. Finally, for empowerment, a stretch and transform approach was mostly identified, due to laws and regulations having such a big effect, but a small amount of fit and conform empowerment was also noted due to the change happening very slowly.

6 The Business Model Perspective

In this section the important business model related factors will be discussed for each firm and a business model canvas summarising the main points will be presented. Please note that firm 8 (NCM), being a foundation and central point of contact for manure processing, will not be explicitly analysed as a business and has instead been used for the previous chapters.

6.1 Firm 1: Farm & full processing installation cooperation (Anonymous)

The first participant's firm is a partnership of 2 companies who together own a manure processing installation. Hereby the contractors own the buildings, while the farmers own the machines. Participant 1 also has their own separate farm with its own business model, but that will not be discussed as it is a fairly standard ordeal. The reason they entered the industry was twofold: firstly, they saw an entrepreneurial opportunity when done at a large enough scale and secondly, they wanted to engage in corporate social responsibility (CSR), seeing it as their duty to help out the environment.

Regarding the installation itself, in total around 80,000 tonnes of manure is processed each year. A screen belt press is used for the primary thick-thin separation, then a dissolved air flotation (DAF) unit is used to separate further particulates from the thin fraction, after which a fine filter and a RO installation is used to separate mineral concentrate from water. The final outputs consist of water, which is disposed in the river, mineral concentrate and dry compost, which is exported.

Key activities: These are mainly the operation and maintenance of the manure processing installation, intake of manure from a large quantity of farmers in the area, sale of outputs, especially the compost, including transportation. This firm is also part of an informal group or club, which he (at least partially) runs.

Key partners: Besides the co-owner of the installation, the aforementioned club has several connections and partners, mainly related to the farmers for which manure is processed and the producer of the manure installation equipment. They also occasionally have some collaboration with research organisations.

Key resources: Arguably the largest resource is having the manure processing installation that has proven technology that actually works, as well as having all the permits and certifications up to date. Of course, they also have all the experience from operating for the better part of 20 years.

Value proposition: The main proposition is the ability for farmers to have their manure fully processed. However, to distinguish themselves from other manure processing installations, they have 3 main focusing points for their value proposition: 1. A reliable company: they always honour their commitments, 2. Quality end-products: their products have multiple certifications, and 3. Competitive prices. Regarding prices, they use an 'at cost-price' model, which almost operates like a not for profit meant for the farmers. The firm makes just a little bit of profit for continuity and unexpected costs, but essentially it is there to 'keep the ball rolling' for all farmers involved.

Customer channels, segments and relationships: These have been combined as it is very simple: the main customers are farms who need their manure processed, and other farmers abroad who require compost. There are no explicit channels to acquire new customers, relying solely on word of mouth. However, this firm does have a unique relationship with its customers. Since it is set up 'by the farmers, for the farmers' essentially some aspects have been made simpler for the farmers. For example, instead of having a complicated sales procedure of individually paying for every step such as first delivering manure and then for the mineral concentrate (including possibly giving money back), they only charge a single fee to exchange their manure for a mineral concentrate that they can use. This fee is also fixed in a contract on a yearly basis. It was noted that some like it, some don't, but at the end of the day it does ensure peace of mind for the customers through consistency.

Revenue streams: There are two main income streams. First, the revenue from farmers bringing in manure to exchange for a mineral concentrate. For reference, different types/forms of manure have different mineral concentrations and water content, so the price is dependent on these factors, which is fixed in the contract. The second revenue stream is the sale of the end products, mainly compost in France.

Cost structure: One of the largest costs is the depreciation and maintenance of the manure processing equipment. Transportation cost to export the compost to France is also a large contributor. Then, slightly less significant are the energy costs, materials (flocculants) needed for the process, and silo costs to store the mineral concentrate (concentrate that the farmers do not want is sold on the market, where they wait until 2022 in hopes of getting higher prices). Labour costs are negligible. What is important to note is that the sale price of compost in France is sometimes less than the transportation cost, so they lose money there. However, they are still required to export it due to the 2013 'mestverwerkingsplicht' and they make up for it with good mineral concentrate prices. Even so, they only barely break even.

Short Summary: Overall, the business model of firm 1 focuses on being a cooperation that is essentially by the farmers, for the farmers. As such, there is a lot of involvement from many farmers and partners in the club and it is priced mostly 'at cost' so that it benefits those who are part of the club/cooperation. However, they do also focus on ensuring the products are of a good quality and that they are a reliable company, so they may not necessarily be the cheapest and/or most profitable, and they also make use of contracts to keep consistency.

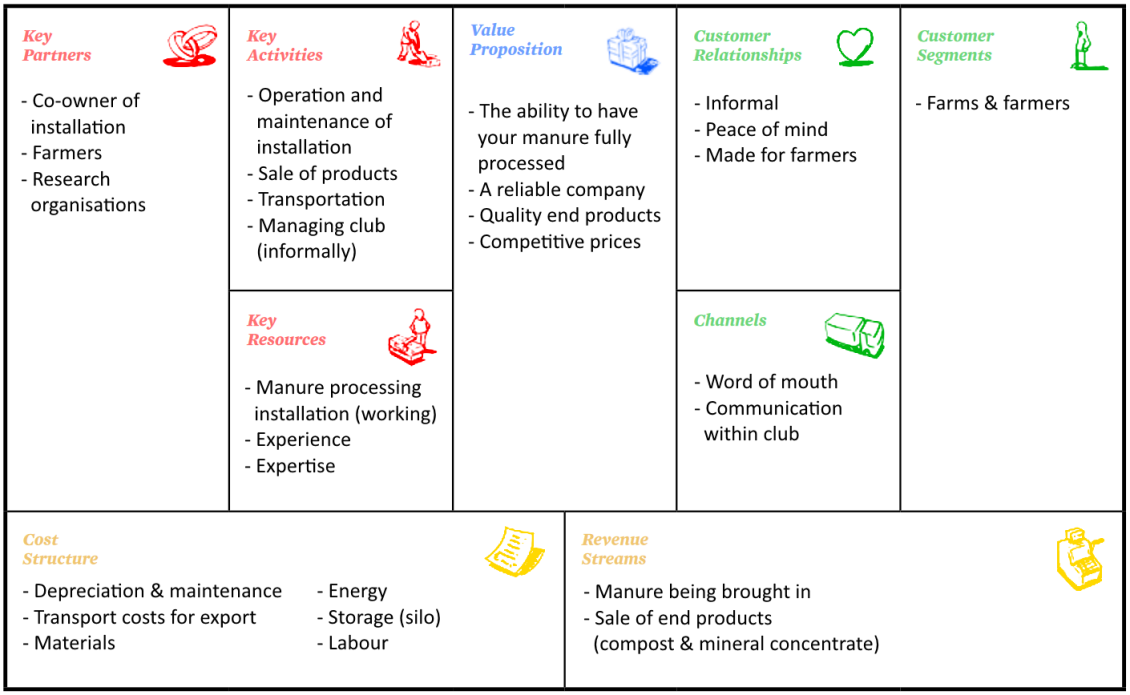

Figure 6.1: Business model canvas for participant 1

6.2 Firm 2: Farm, processor, and large full system producer (Kempfarm)

Like firm 1, this firm started out as a normal farm, raising cattle and pigs, where they then decided they wanted to do something with the manure, out of passion for technology and because they wanted to reduce waste. However, that is where the paths split. They focused on making their own system and started processing their own manure in 2004, which then expanded to producing manure systems for other farms and also processing other farm's manure since 2010. In 2019 they had to stop processing manure due to permits, but they have since moved to another location.

Regarding how manure is processed is similar to firm 1. They start by adding chemicals (flocculants) to make the thick-thin separation easier, which is done via a belt press. The thick fraction is then hygienised and composted, whereas the thin fraction passed through a DAF unit, then RO, and then possibly ion-exchangers (depending on if the remaining water is disposed of in the river or not) to make the mineral concentrate.

Key activities: Everything related to the creation, sale and maintenance of manure processing installations. They also sometimes offer advice to other installations.

Key partners: They mainly collaborate with farmers (their main customers) and other manure processing installations. Quite often banks do not easily finance manure processing installations due to the high risks and low profit margins associated with them. Because of this, this firm often works with either pre-financing upfront or they take partial ownership of the new installations they set up. Interestingly, although they produce equipment, they did not mention explicitly collaborating

with research institutions. Also, they did reach out to other countries to expand their market, but this has been somewhat unsuccessful so far since the uniquely high manure price in the Netherlands makes manure processing systems too expensive for other countries.

Key resources: As a systems producer, their main resources are the knowledge and experience to produce systems, as well as the equipment necessary to produce them. Also, as a form of payment, they take partial ownership of some installations, meaning that these are also part of their resources.

Value proposition: The main proposition is that they are one of few (according to them 2) manufacturers that consistently produce good quality, well-working installations. They noted that their installations may not be cheap, but they just work, unlike many other inferior competitors. Manure can be harsh on components and low quality components do not last the many years of hard use that is required to recuperate the cost. They are also sometimes asked to come to other farm's installations to help them with their setup.

Customer channels, segments and relationships: This is very similar to firm 1, where the main customers are farmers or groups of farmers looking to set up a cooperative installation, with no explicit channels or even an up to date website and relying purely on word of mouth to sell their products. Notably, since they sell systems, their systems are occasionally in the news and they sometimes join lectures/readings where they can acquire new customers. As they would say "if they really are interested, they will know where to find you." In terms of relationship, they are also part of an informal community where a lot of their customers are in and they also offer assistance to their customers if anything ever goes wrong with their installation.

Revenue streams: The main revenue streams (besides their normal farm) come from selling manure processing systems and from profit-sharing with the installations they partially own. Since every case is different, they are cost-price driven, meaning that the price they charge is whatever it costs them plus a fixed margin on top. It really depends on the specific case and they only have a few projects per year.

Cost structure: Not much was mentioned about their costs, but seeing as they mainly produce and operate manure processing installations, the largest costs are related to the materials, equipment and possibly labour to create these systems. With the profit sharing they receive from their partially owned installations, it is unclear if they also are actively involved in the revenue and cost streams of that operation or if they only take the profits. Purely speculating, being actively involved in the accounting of the roughly 20 installations in their network is likely to be too intense, so they likely just take the profit share.

Short Summary: Although their business model does include processing manure, their main focus is on selling whole systems. The systems may not be cheap, but they work and should last a long time, unlike many other inferior competitors. To help cover the cost, they also offer to take partial ownership and profit sharing from the installations they sell as a form of payment. Furthermore, they are also part of a community, where they are open to offering assistance and have many connections.

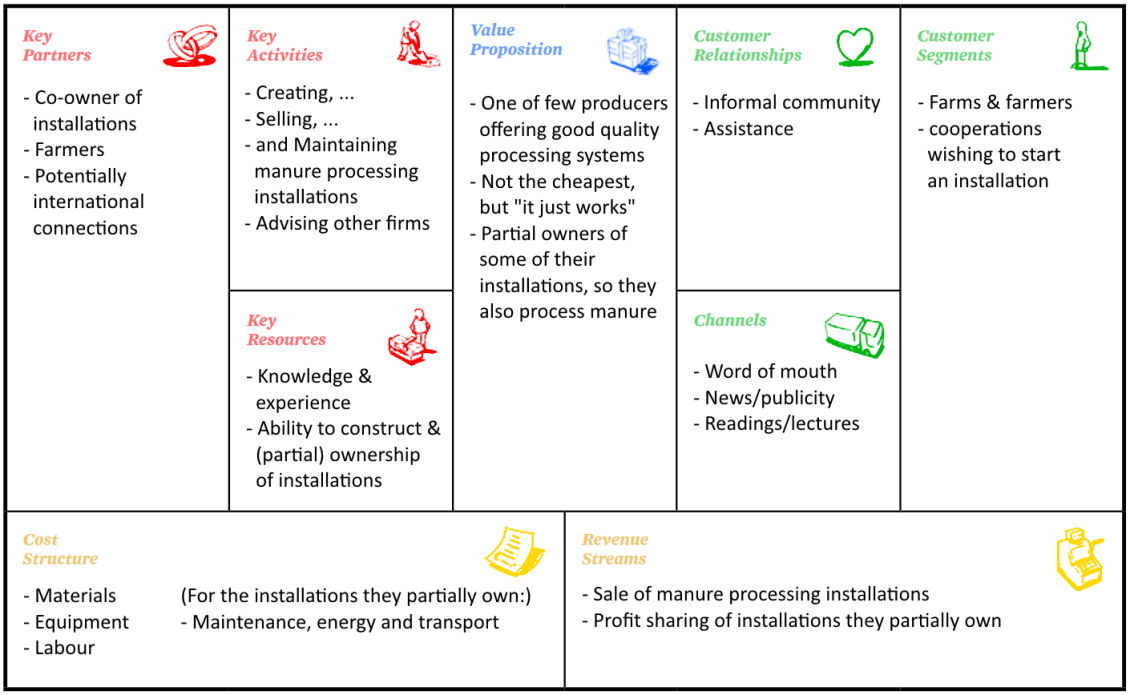

Figure 6.2: Business model canvas for participant 2

6.3 Firm 3: Technology developer and systems producer (MEZT)

Unlike the other firms, firm 3 did not originate from the agricultural market and instead entered the industry through a collaboration with the TU Delft. The TU Delft had underused patents available, one of which was related to a novel method of manure processing. Thus, when they had the possibility to use that patent at the height of the 2019 nitrogen crisis, firm 3 took the opportunity to start an entrepreneurial venture in an environmentally friendly direction. Being one of the youngest firms interviewed, their business model is not entirely 'set in stone' yet, but they do have a general vision/heading of where they aim to go to.

Within their firm, the focus is on their bi-polar membrane electro dialysis (BPMED) unit, which is the part they got the patent on. This technology allows for finer and more efficient mineral extraction than traditional methods. The idea is that the other steps of the process are already fairly well established (e.g. separators, tanks, etc.) so those can be made by other manufacturers well, but they make the BPMED and buy the rest in to make a system.

Key activities: Their activities are related to everything surrounding the development and creation of their processing step. Unlike some other firms, they do not develop and create the entire system themselves, but rather focuses on their puzzle piece in the solution train and uses other suppliers for the rest of the system. In fact, even for their own puzzle piece they sometimes use parts or help from other suppliers. Thus, the focus is not only on creating the overall system, but also heavily on development and research to improve their puzzle piece and networking to acquire new expertise and to identify possible opportunities.

Key partners: Since they use many other suppliers to create their system, it should come as no surprise that they have many partners. Their partners include practically everyone in the supply chain they can get their hands on, including component suppliers, research institutions, the original patent developers, a subsidy advisor, general agricultural equipment suppliers, and even those who may not be the direct customers of the product but are still affected by the supply chain, such as animal feed producers and parties interested in the outputs of the processing equipment, as well as purchasers of agricultural goods. By developing their system with everyone taken into consideration, they can create what is hopefully the best system possible.

Key resources: Being a younger firm, they do not have the large quantities of physical resources or capital available to them, instead working largely with subsidies to fund their development. However, despite being young, they have already built up a lot of intangible resources, from network connections to patents and rights to the technology (currently 5 or 6 patents) and specialised expertise for their specific puzzle piece on which they are focusing.

Value proposition: Some argue that their technology is the most promising technology of all manure processing technologies, quoting that it could be the "holy grail of processing." Like some other technologies in the manure processing industry, it tackles the emissions at the source: manure, instead of the stable with an air scrubber. However, the technology promises higher extraction rates, no chemical usage (such as flocculants) and lower energy usage (only a little bit of electricity is needed and no heating) than competing systems.

Customer channels, segments and relationships: So far little effort has been spent on this. Potential customers mainly approach them based on publications, articles in the news, websites, etc. As firm 2 said; "they will know where to find you" applies here as well. Eventually they want to grow rapidly and (ambitiously) want to provide most of the Dutch market with their systems in the future, however, they would like to first complete the testing of their system before starting to actively acquire customers. Nonetheless, during the development they try to keep in touch with firms who may be involved and actors who may be affected.

Revenue streams: They mainly aim to make money by having the idea of the specialised puzzle piece (the patents) and optimization of the technology application. Eventually, besides selling their piece they may also sell entire systems using components from other suppliers. Whether they will also do the maintenance in the long run is still unclear. In essence at the moment they are taking an almost "hands off" approach where a large part of the system is made by others, however, this also means that those others take a larger part of the revenue streams.

Cost structure: Also related to the "hands off" approach, their cost structure is fairly low, with few employees and little overhead. Currently they are still in the testing phase of the system, and even in the future, continuous improvement to the system and technology is part of their plan to remain on top. One could also consider patent costs, but if the firm grows to a large scale, these will be relatively small.

Short Summary: The main focus is on improving and developing their innovative part of the system. In the process they use a lot of partners and connections to help them out, also with the parts of the system they do not produce themselves, and as mentioned just now, they have more of a "hands off" approach, being more of a technology and idea provider.

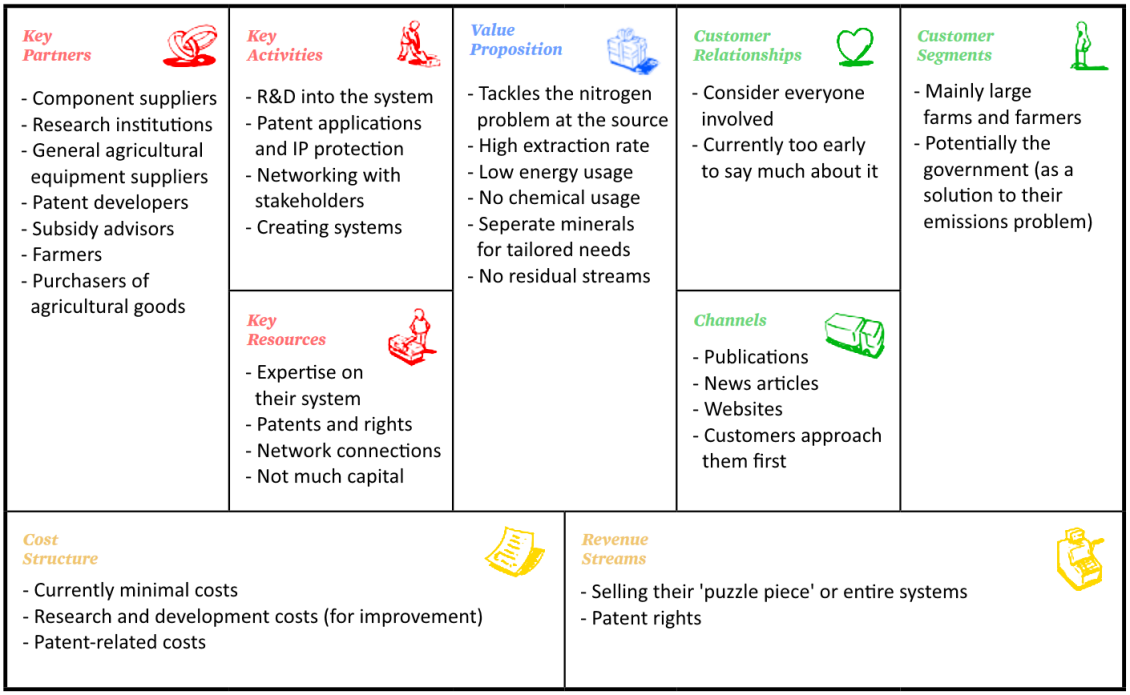

Figure 6.3: Business model canvas for participant 3

6.4 Firm 4: International technology provider (Colsen)

This firm has different roots from the other firms as well. It was founded by a technological entrepreneur over 30 years ago who had a good idea for the food processing and waste water purification industry and thus started a family business. This idea to recover energy and valuable substances then grew and expanded to also cover manure processing, as it was supported by their core values and competencies. Since they do many processes surrounding liquid remnant streams and recovering nutrients from these streams, their market is more international, having operations in Spain and South Africa, but their core is still in the Netherlands where all the research and innovation is done.

Regarding the technology and systems themselves, they are quite broad, having systems for manure fermentation, biological desulphurisation process to recover sulphur from biogas, nitrogen strippers to recover ammonia, and general thin fraction recovery to make pure(r) water and minerals, which is for both the waste water industry and the manure processing industry.

Key activities: Much like firm 3 and somewhat similar to firm 2, their main activity is providing technical know-how, components, and turn-key systems for manure processing (as well as other streams). However, unlike other firms that were interviewed, they do not do after sales or maintenance, which is instead done by the purchasing firm themselves or outside contractors. This is for several reasons. First, they tend to sell large installations to large firms, meaning they often have the capabilities to do their own maintenance, secondly, being an international firm, it is very difficult to provide such service abroad (and not lucrative), and thirdly, their installations have limited mechanical service requirements (such as no reverse osmosis membranes that need to be replaced relatively often).

Key partners: They are essentially desk/office people, meaning that the construction of systems and components and acquiring of parts is all done through contractors. As such, they partner with many contractors, some of which they may only need one part from one supplier. Similar to other firms as well, they work with research institutions to stay innovative and ahead of the game, having interns and graduation projects for students. They also have some limited cooperation with the government (e.g. for acquiring subsidies) and trade associations. Also, connected to their international background, they have international contacts, including governments and ministries and even large international project finance firms to finance those projects.

Key resources: Due to the nature of being a technology provider focusing on designing and guiding the creation of systems, but delegating the construction to contractors, their key resources include a broad expertise (also outside of manure) with lots of experience and international capabilities and relations.

Value proposition: Their main proposition consists of 4 points: First, they offer high quality systems. Secondly, they have lots of technological expertise and capabilities to create different and complete installations/setups. As they say, they have knowledge on both biogas installations and regular manure processing, whereas other competing firms usually are specialised in only one of these. Also, they can even help with permit and subsidy applications, which combined means a total unburdening for the customer. Thirdly, they are very flexible in cooperation and working. If some firms want to (for example) really make one part of the process themselves to get their margins, they can do it without a problem. In such a case Colsen can then provide the technical drawings of what works for their system and charges only a small engineering fee. This means that besides offering turn-key installations they also offer a lot of non-turnkey installations and customers appreciate this flexibility. Finally, with the firm existing for approximately 30 years, they have a good track record with lots of experience and are able to show many successful installations.

Customer channels, segments and relationships: As with other interviewed firms, there are no specific channels or methods to acquire or retain customers, relying largely on word of mouth and the alike. What may be notable to say is, as mentioned previously, their customers appreciate the flexibility they offer, which may help with relations.

Revenue streams: The main income is generated through the sale and construction of new installations. Occasionally they also like to take a stake in the firm they sell their system to, especially greenfield projects, which allows them to offer a discount to the purchasing firm, while giving Colsen lasting revenue streams. However, right now it is still a limited part of their income though. They also generate a small income from the innovation work they do (which is necessary to keep on top of the game), but that is never cost covering.

Cost structure: Their main costs are the research and development costs. Having office employees; these need to be paid, as well as the prototyping and experimentation, all in order to stay innovative. Of course, they also have the costs of creating the system, but since this is done through contractors and funded by the sale of new installations, they do not 'feel' the full brunt of those costs so to speak.

Short Summary: The main focus is on providing the technological know-how, components and turn-key systems for a wide variety of needs. As such, they also have a main focus of research and development (R&D) and improving their knowledge to ensure good quality systems. Furthermore, they have a sizeable list of partners, especially for the construction of their systems, which is often outsourced. Finally, they are also quite flexible, both in providing solutions and helping out.

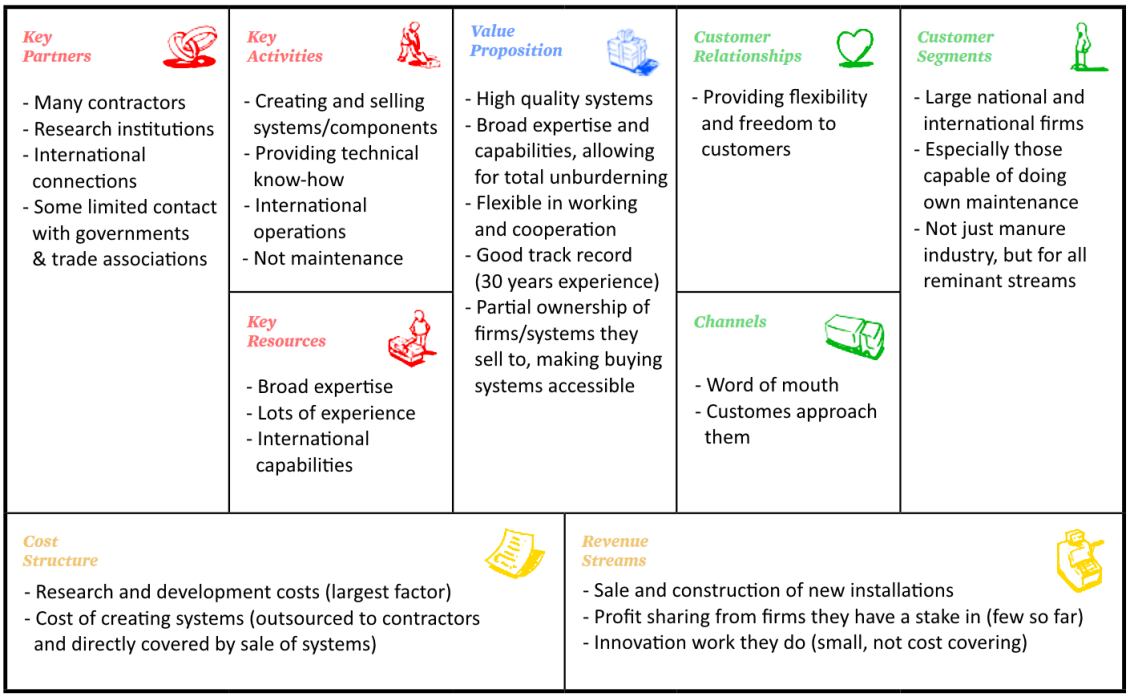

Figure 6.4: Business model canvas for participant 4

6.5 Firm 5: Farm and large independent processing installation (Vlako)

Firm 5 is a family run business, which much like firm 2 originally started out as a farm that then expanded to include a manure processing installation. They made the installation themselves and it is not bought from anyone else. Their installation is also quite large, processing 135,000 m^3 of manure per year and 90% of that comes from farmers in the region.

The manure processing system is similar to others, albeit using slightly different components. First, a manure press is used to separate the thick and thin fraction, where the thick fraction is hygienised for export and the thin fraction passes through reverse osmosis and a nitrogen (ammonia) stripper to make the mineral concentrate and water.

Key activities: Much like firm 1 and 2, they have a farm and a large manure processing installation that processes manure of their own farm and those in the region. However, where firm 5 differs is that they do not sell their own systems, nor do they have a cooperation with other farmers. Instead, their installation is fully independent of others.

Key partners: The reason for their installation being independent is partially because they made it all by themselves from parts and components. As such, they have very few to no partners for creating, running or maintaining the installation besides themselves. They do however have a few other partners, namely from the government and Wageningen university, since they ran a (now completed) pilot program, some media coverage, certifying bodies such as KIWA and some firms with knowledge and innovation, presumably to help them out initially with the installation and eventual expansion/upgrading.

Key resources: Besides their regular farm, they made their own large installation from scratch, which in itself is a key resource, not just physically, but also experience-wise.

Value proposition: They listed 3 main points as their value proposition: 1. A market conform manure purchase price. Farms eventually go to the cheapest manure processing installation close by anyway, so they keep their prices low. This is possible as they have an established rural location which is written off (i.e. not a greenfield location anymore) and thus they have a cost-technical advantage. 2. A good running installation. They are able and have the capacity to take in all manure that comes their way. 3. They follow up on expectations and promises, which ensures trust and returning customers. Also, they have few employees, so it is less of a 'business meeting' culture where everyone tries to push their own ideas and nothing happens. Instead, they can quickly make moves with little effort and they can work very goal-oriented. On top of that, having fewer employees and people involved is cheaper too.

Customer channels, segments and relationships: It is just like all the other firms so far; a combination of word of mouth, knowing the customer beforehand, etc. Useful to note, they say that with their 3 value proposition points, they have everything under control and that it ensures that the manure and people comes to them. What is also useful to point out is that unlike firm 1, they do not establish many contracts with their customers. At the start 50% made a contract, but since then there have been more installations to offer service and lower manure prices, which gives more freedom to the regular farms providing manure. Also, most farms have already experienced 2-3 instances in the last 10 years where they had a contract or invested money into a project and

it ended up not working out. Thus farmers do not want to restrict themselves with a contract. In the cases where they do want a contract, it has to be cheaper than the market price for them and even then it will be just a small quantity, to keep a "foot in the door" so to say and still have freedom with the rest of their manure. Because of this, one can say that there isn't much done for relationships as it is based on offering the cheapest price in the region.

Revenue streams: Their main income (besides the regular farm) is from the intake of manure and perhaps selling some of the excess mineral concentrates that are not used on their farm. What is very interesting to note is that they do not make use of any subsidies at all, and yet they are still profitable (although they noted it is not something they will get rich from). This is in contrast to some other installations that cannot function profitably without subsidies.

Cost structure: The costs include everything related to manure processing, including energy, labour, maintenance (all roughly equal) and additives (polymers and iron sulphates which account for 30% of the cost). Most likely their large size, almost written-off land, few employees, and that they managed to successfully make their own installation without needing much help from others likely made their cost structure low enough to be able to operate without subsidies.

Short Summary: The main focus for the installation of firm 5 is independence, where they have relatively few partners, but thus also more flexibility and ability to act quickly. With this in mind, they do not make contracts but instead rely on a cheap manure price to ensure the capacity of their system is filled. Nonetheless, they still have a good working installation and are trustworthy, which also helps ensure customers return.

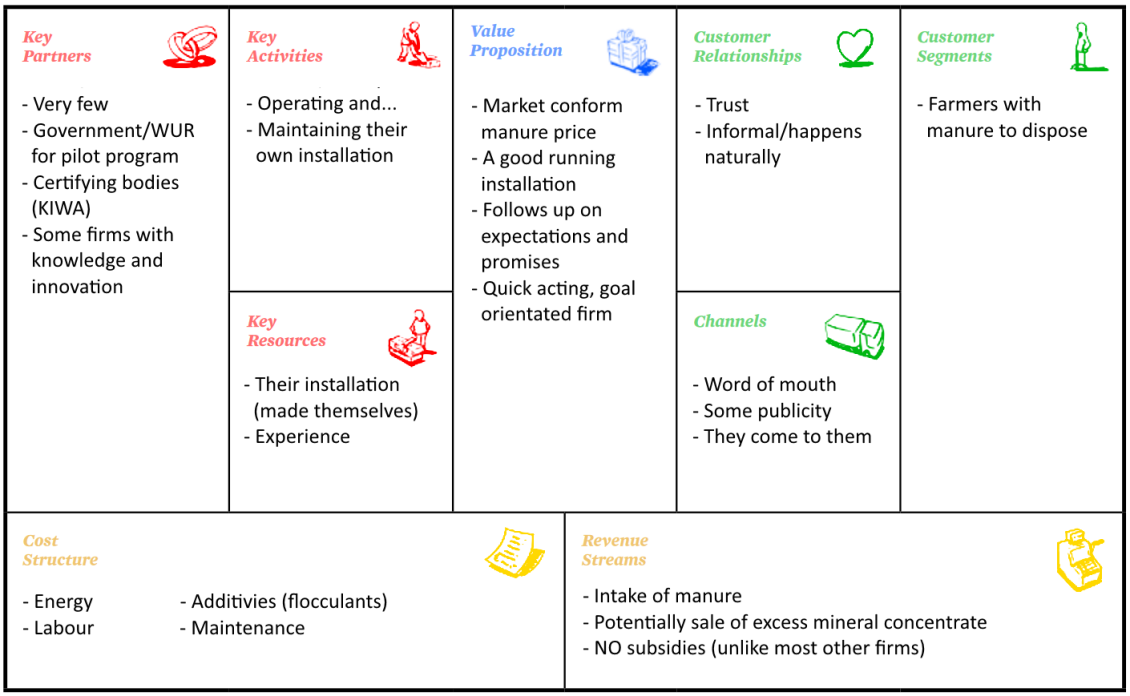

Figure 6.5: Business model canvas for participant 5

6.6 Firm 6: Full processing installation cooperation (Mestac/Merensteyn)

Firm 6, Mestac, started out 30 years ago as a manure distribution and transportation firm and after the manure processing requirement law ('mestverwerkingsplicht') was introduced decided to process manure as a cooperation, starting from 2015 with their installation Merensteyn. Their main motivation was that they thought that in the future there would likely be more manure processing (especially in the south-east of the Netherlands where they are located) and they wouldn't be able to survive on distribution alone. Since then their cooperation has accumulated over 300 members and now processes around 170,000-180,000 t/yr of manure.

The installation exclusively processes pig manure with a setup similar to other interviewed firms, utilizing a thick thin separator, exporting the thick fraction, and using RO to make a mineral concentrate and water (to be disposed of in the river) out of the thin fraction. Although Mestac still has its distribution and transport branch, this business model analysis will focus on their manure processing installation Merensteyn. Their business model is very similar to firm 1, so the differentiating factors will be mentioned.

Key activities: Like firm 1, intake and processing of manure, operating and maintaining the installation, sale of goods (mineral concentrate and thick fraction) and (for general Mestac) transportation.

Key partners: Being a cooperation they have many connections and people they work with, including farmers, suppliers, feed producers (customers for their mineral concentrate), the NCM and even competitors of them where they share knowledge and learn from each other.

Key resources: Like firm 1, they have a good working manure processing installation, with up to date permits and certifications, and of course the experience from improving and perfecting their installation.

Value proposition: The basic proposition is similar to firm 1, but it varies slightly, focusing more on good service and transparency at the cost of slightly higher prices for farmers. Their main proposition points are as followed:
1. Transparency. They are a like a public company where anyone can walk into their factory to take a look, with numbers and data being shared publicly with their members. This also ensures legal compliance. Furthermore, the cooperation has a council of members with managers and leads elected by the members.
2. A consistent and reliably good service. If a farmer signs up for the contract, they will always come pick up manure. Not only that, everything is just taken care of, with transportation and invoices also being made, reducing the burden for the members. Also, if something unfortunate happens, they will always try to resolve it.
3. Flexibility for the members. Although they offer a very reliable service, they also have a large enough scale to offer flexibility. If one farmer wants to offload manure once a month or every week, it is possible to do so. Similarly, if one week a member wishes to dispose of a little bit more or less, it is possible, as their scale is large enough to balance out with other members. However, they did note that this came at a cost. Being one of the largest and most transparent in the region, competitors always try to undercut them slightly, so they are slightly on the expensive side. However, they believe their service is worth it.

Customer channels, segments and relationships: Like with firm 1, the members sign a contract, essentially forcing manure to be continuously sent to the installation and ensuring consistency. However, many members also invest in the installation to cover the cost, meaning they want to be dedicated to the service so they get their money's worth out of it. Besides contracts, there is also a small amount of capacity left for the free market. Regarding relations, they acquired a lot of their current customers through contacting previous customers of their Mestac distribution service, but they also visited (new) farmers to attain new customers. However, since they started soon after the 'mestverwerkingsplicht' was introduced, there was already a lot of demand for it in the local area (south-east Netherlands).

Revenue streams: Like firm 1, the revenue is mainly from farmers bringing in manure and the sale of the thick fraction and mineral concentrate. Currently selling the thick fraction still costs money, although the cost is slowly coming down. Selling mineral concentrate has recently also become profitable, especially due to recent increases in energy prices pushing fertilizer prices up.

Cost structure: Again, similar to firm 1 it is all the costs related to operating the installation (energy costs, depreciation, labour, etc.). For the entire installation they only have 5 permanent employees, split roughly 50/50 for running the installation and for administration.

Short Summary: The focus is very similar to firm 1, having a cooperation with many partners and contracts for consistency. However, where it slightly differentiates is that there is perhaps a stronger emphasis on transparency, being completely up to date on all permits and certificates and being completely compliant. Also, they focus on having a consistent, reliable and all-inclusive service for a total unburdening, but this does result in a slightly higher manure disposal price.

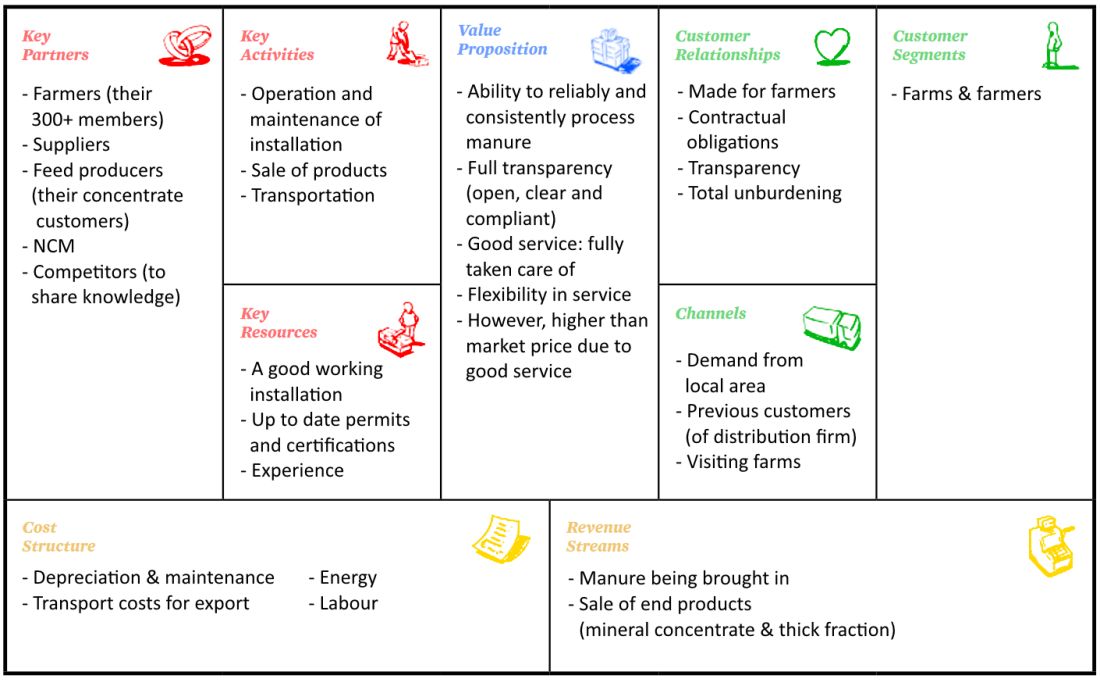

Figure 6.6: Business model canvas for participant 6

6.7 Firm 7: Large full processing and biogas firm (Twence)

Firm 7 is a large waste processing and energy firm that since around 2015 decided to also go into the manure processing industry. However, unlike other interviewed firms, they are a government dominated firm with 15 municipal shareholders. This means that the focus is more on solving the societal problem of the manure surplus and fulfilling their vision to create/save substances and make green energy rather than pure profitability. With this in mind, they call themselves a sustainability promoter with 3 core program lines: circular economy, sustainable energy, and producing raw materials, which manure processing is a part of.

Regarding their installation, the manure first goes through a thermophilic fermentation process to create biogas which is added to the gas network. Afterwards, the digestate is separated into a thick and thin fraction, where the thick fraction is hygienised and exported to East Germany (25,000 t/yr), and the thin fraction goes through osmotic membranes and then an evaporator to further separate the mineral concentrate. In the end, 250,000 tonnes of pig manure is processed per year, resulting in 15,000 t/yr of K_2O fertilizer, 3,000 t/yr aqueous ammonia, and 200,000 m^3 of water and 5,000,000 m^3 of biogas. Also, their installation is nearing the end of construction, but won't actually be fully running until mid-2022, so like firm 3, their business model is still subject to change.

Key activities: Besides their main waste processing installation (which is not covered here), their main activity is everything related to the construction, operation and maintenance of their manure fermentation and processing plant.

Key partners: For the manure intake they almost exclusively work with intermediaries (the 'loonbedrijven' that take and transport manure), especially the larger scale ones, but they do not actually work with farmers themselves. These same intermediaries export some of their products. For their system, they work with 3 suppliers for the technology that also do the construction and maintenance for them. They also work with research institutions for the relatively new thermophilic fermentation process they use. Finally, they have a little bit of contact with competing fermentation firms, but they do not want to give away their differentiating technology, so they don't share that much.

Key resources: Like with several interviewed firms, their main resource is having a working manure fermentation and processing installation, with good quality products. However, still being in the construction phase means they do not have the same level of experience as other participants.

Value proposition: Being a government-based firm, although they should not lose money, they do not have to reach the same level of profitability as a private firm, which gives them more options. For example, they don't want to create any nuisance to the neighbourhood, so they use washers/scrubbers to remove the smell and have their manure transportation travel via special routes to reduce the load and nuisance of trucks in the region. They have a strong vision to close the cycle and do it well, so they demand a high quality for their products with no waste streams. However, the value proposition is not limited to society. The customers who bring in manure do not need to invest money into the installation or be a member of a cooperation, so they do not have a chance to lose money to an unsuccessful installation, ensuring safety. Also, they focus on setting up contracts to ensure continuity and consistency with a reliable service, following a set schedule. However, all these benefits cost money, so their price is not the lowest.

Customer channels, segments and relationships: To acquire customers, they first looked at their intermediaries to see if they can contact farmers through them and sign a contract or to form a contract with intermediaries directly. However, unlike practically all other interviewed participants, they did have quite a bit of active promotion, including Facebook actions, an online broadcast with farmers, and sending their sales team to go to farmers and have a chat with them around the table. Regarding relations, originally they wanted very long term contracts (for their continuity and consistency), but farmers weren't very happy to do that, so now they look at shorter 3-year contracts, which is where the majority of their capacity comes from. After all, he noted that you cannot easily avoid a contract, since everything has to be formally documented and monitored. Because of this they do not do individual 'at the door' manure intake.

Revenue streams: Revenues are straightforward, coming from the intake of manure and from selling their products. Interesting to note, unlike many other manure processors that just make a general mineral concentrate, they have a further evaporator step to separate it into aqueous ammonia and a potassium fertilizer (K_2O), however, they are having a hard time finding buyers for this potassium fertilizer and thus prices are currently quite low. Nonetheless, they hope that their long-term focused plan pays off in the end.

Cost structure: These include costs for constructing and running the installation, such as maintenance, energy, labour and chemicals needed for fermentation and their air scrubbers just to name a few. Also, similar to several other firms, exporting their phosphate (thick fraction) is still costing them money.

Short Summary: The focus of their business model is more on society and sustainability rather than profitability. This includes having low nuisance for those close to the installation, high quality certified end products, and a vision to close the cycle. They also work with quite a few partners to do things for them, including building the installation and transporting manure to the installation. However, because of all this, and similarly to firm 6, they are not the cheapest.

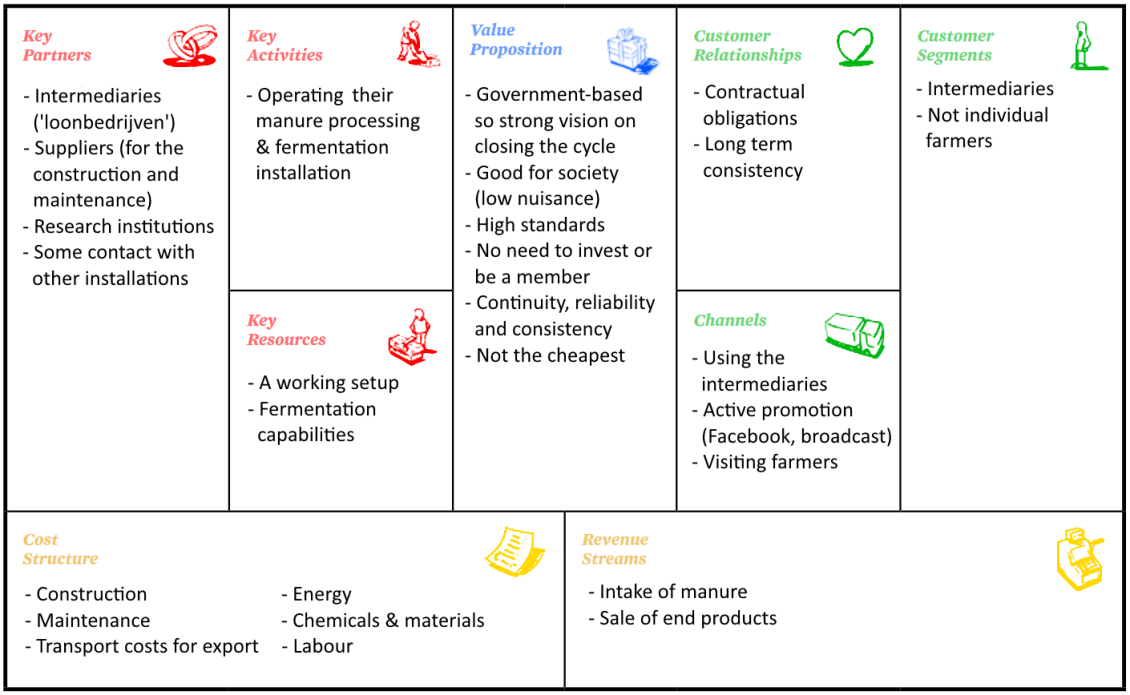

Figure 6.7: Business model canvas for participant 7

6.8 Summary of business model canvases

In this subsection a summary of all the different business model canvas aspects for each participant is made. This summary can be found in tables 6.1 and 6.2 on the following pages. For the summary, some of the terms were shortened to fit into the table, such as 'research organisations and institutions' being simply referred to as 'researchers'. Also important to point out is that sometimes firms used different terms for essentially the same point. For example, for the partners, some firms partnered with 'firms with knowledge and innovation', some with 'other installations to share knowledge' and others with 'competitors' but eventually these all mean the same thing: other installations that may or may not be competitors and that likely have good knowledge to share. Where possible these different terms were homogenized to make the analysis and cross-case comparison easier in the following chapter.

Table 6.1: Overview of partner, activity, resource and value related BMC points of all firms

Participant: → BMC part: ↓	**Firm 1: Anonymous**	**Firm 2: Kempfarm**	**Firm 3: Mezt**	**Firm 4: Colsen**	**Firm 5: Vlako**	**Firm 6: Mestac**	**Firm 7: Twence**
Key Partners	-Farmers -Researchers -Co-owner	-Farmers -Co-owner -International connections	-Farmers -Researchers -Suppliers -Subsidy advisors -Patent developers -Purchasers of agri. goods	-Researchers -International connections -Contractors -Government -Trade associations	-Government -Certifying bodies -Other installations	-Farmers -Suppliers -Feed producers -Other installations -NCM	-Researchers -Suppliers -Other installations -Intermediaries
Key Activities	-System operation -Maintenance -Product sale -Transportation -Managing club	-System operation -Maintenance -Product sale -Giving advice	-Creating & selling systems -R&D -Networking -Patents & IP protection	-Creating & selling systems -Giving advice -International operations	-System operation -Maintenance (-Product sale)*	-System operation -Maintenance -Product sale -Transportation	-System operation (-Product sale)*
Key Resources	-Working system -Experience -Expertise	-Knowledge -Experience -Ability to make systems -Partial ownership	-Expertise -Patents/rights -Network connections	-Expertise -Experience -International capabilities	-Working system -Experience	-Working system -Experience -Up to date certifications & permits	-Working system -Fermentation capabilities
Value Proposition	-A good running system -Reliable firm -Quality products -Competitive prices	-High quality systems -Not cheap, but it just works -Partial ownership	-Tackles nitrogen problem at source -High extraction -Low energy consumption -No chemicals -Separated minerals -No residuals	-High quality systems -Broad capabilities for total unburdening -Flexible -Good track record (30 yrs) -Partial ownership	-A good running system -Conform prices -Reliable firm (follows up on expectations) -Flexible & quick acting	-A good running system -Reliable & consistent -Good service for total unburdening -Fully transparent -Flexible service -Slightly higher prices due to good service	-Strong vision to close the cycle (gov. based) -Good for society (low nuisance) -High standards -No need to invest or be a member -Continuity, reliability & consistency -Not the cheapest

Note: NCM (firm 8) not included due to being an expert/point of contact
*Starred points are not explicitly mentioned by firm, but are still part of their business model.

Table 6.2: Overview of key customer segment, relationship, channel, cost and revenue related BMC points of all firms

Participant: → BMC part: ↓	**Firm 1: Anonymous**	**Firm 2: Kempfarm**	**Firm 3: Mezt**	**Firm 4: Colsen**	**Firm 5: Vlako**	**Firm 6: Mestac**	**Firm 7: Twence**
Customer Segments	-Farms/farmers	-Farms/farmers Cooperations who want to start an installation	-Large farms & farmers -Government as a solution to the nitrogen problem	-Large national & international firms -Those capable of doing their own maintenance -Not just manure but all reminant streams	-Farms/farmers	-Farms/farmers	-Intermediaries -Not individual farmers
Customer Relationships	-Informal -Peace of mind -'For farmers'	-Informal community -Assistance	-Consider all who are involved -Currently too early to say	-Providing flexibility & freedom to customers	-Informal (happens naturally) -Trust	-'For farmers' -Contractual -Transparency -Total unburdening	-Contractual -Long term consistency
Customer Channels	-Word of mouth -Communication within club	-Word of mouth -News -Publications -Readings & lectures	-News -Publications -Websites -Customers first approach them	-Word of mouth -Customers first approach them	-Word of mouth -Some publicity -Customers first approach them	-Demand from local area -Previous customers -Visiting farms	-Using intermediaries -Active promotion (e.g. Facebook, broadcasts) -Visiting farmers
Revenue Streams	-Manure intake -Sale of products	-Sale of systems -Profit sharing	-Sale of their 'puzzle piece' or whole systems -Patent rights	-Sale of systems and their construction -Profit sharing -Innovation work	-Manure intake -Sale of products -No subsidies!	-Manure intake -Sale of products	-Manure intake -Sale of products
Cost Structure	-Labour -Maintenance -Depreciation -Materials -Energy -Storage (silo)	-Labour -Maintenance -Materials -Energy -Equipment -Transport	-R&D costs -Patent costs -Currently minimal costs	-R&D costs -Cost of creating systems (which is outsourced to contractors)	-Labour -Maintenance -Materials (additives) -Energy	-Labour -Maintenance -Depreciation -Energy -Transport	-Labour -Construction cost -Maintenance -Materials & chemicals -Energy -Transport

Note: NCM (firm 8) not included due to being an expert/point of contact

7 Identifying Patterns & Links

7.1 Overlap and patterns in business model aspects

Before the final different business models can be identified, the overlap and main differentiating factors need to be identified. At the start of this paper the distinction between firms was already made in terms of firms that actually process manure and firms that make and sell equipment in order to process manure. These differentiating factors clearly return here.

Also, as mentioned earlier on, the firms that only hygienise and possibly separate manure for export are excluded. Those firms generally have a focus on transportation and the separation/hygienisation is a means to get to the transportation.

There is quite a lot of overlap between firms in terms of business models. Generally speaking (with a few specific exceptions) most firms had...

- The same customers consisting of generally large farms and firms who wish to have their manure processed or who wish to start processing manure and (for equipment producers) sometimes these firms are operating internationally.
- Nearly identical relation channels, being word of mouth, appearing in news/publicity and that the customers approaches them first instead of actively trying to attract customers. However, occasionally the firm may visit the farm as well and only one firm participated in active promotion.
- Similar key resources consisting of either a working installation or the capability to make one and if they have existed for some time, a good amount of experience, expertise and knowledge.
- Roughly similar basic types of key partners consisting of farmers (or the intermediaries that transport manure from the farmers), research institutions and suppliers when the installation was made. However, it should be noted that not all interviewees explicitly mentioned suppliers even though they were necessary when originally making their installation.
- Roughly similar basic value propositions of offering an installation or service that just works, a good quality product/service and a reliable company/service.

Meanwhile, there were also a few differences between the interviewed firms, mainly consisting of...

- The source of their key activities (either operating or creating systems, or both) where some firms do or do not also do maintenance themselves...
- ...which also affects their key incomes and expenditures, which is different for each firm, except for labour, although labour costs vary quite significantly (relatively low for manure processors, but high for system producers).
- Some differences in key partners (with some firms having or not having government connections, international connections and contractors).

- Some differences in their value proposition (possibility for partial ownership to pay off/share costs, ability to act quickly or be flexible, and for processors; either having market conform/competitive prices or offering a better, all-inclusive service but at a higher price).
- A distinct difference in customer relationships either being relatively informal and trust based, or relying on contractual obligations. Please note, this is focused on the relationship, since even a firm that uses contracts for consistency may have listed trust as being a vessel to acquire the contract in the first place.

An overview of the key similarities and differences between all the identified aspects of the business model canvas can be found in figure 7.1. Please note that the "different aspects" in orange can be for both installation producers and for manure processors, whereas the blue and green coloured text is specific to only equipment producers and manure processors respectively.

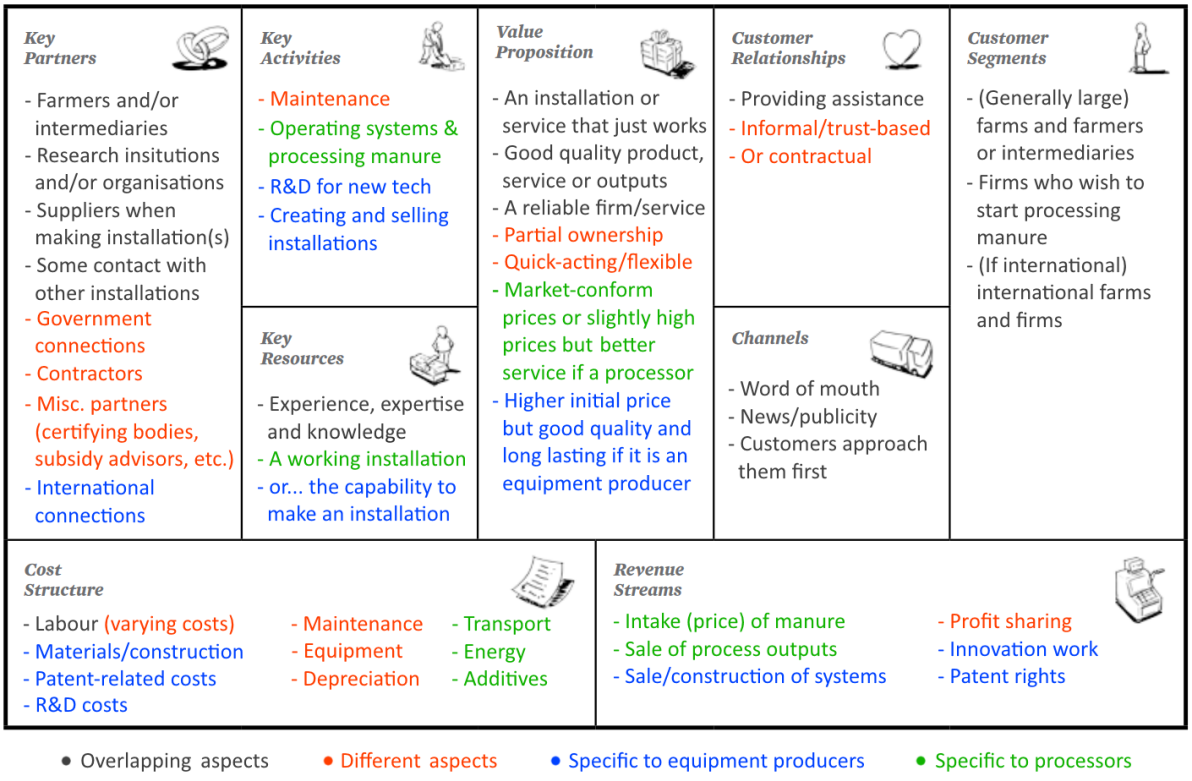

Figure 7.1: Key differences in business model canvas aspects

7.2 Key identified (successful) business models

Using the overlap and differentiating factors between the interviewed firms, a few different business model classifications have been made. There may be more business models out there than have been identified here, but these are the ones that were found during the analysis.

7.2.1 Manure processors

a. Large one-owner installation: Here, one owner has a large installation that processes manure for multiple farms in the area. By having only one owner, everything is "in your hands", meaning the owner has full control and is generally more flexible and responsive. Moreover, the large size allows costs to be low enough to be feasible. One participant managed to use this business model without even using subsidies; something that is not possible for a smaller system that only processes its own manure.

b. Cooperation of multiple (smaller) farms: Similar to the previous business model, processing for only one farm is too costly, so many farmers come together to operate a shared installation. These are generally not separate for profit entities (or at least they do not appear to act like one), instead being operated by one of the large members of the cooperation to collectively reduce the cost of all farmers taking part in the project. Contracts are common here as it requires commitment from many members and often members are a key source of investment to get the operation up and running.

c. Small one-farm only processing: These were not interviewed, so it is purely an educated guess and speculation, but based on the other interviews and their insights, these farmers/systems tend to barely break even (if at all) due to their small size and high (initial) costs. From searching the initial firms, these installations do not appear much in media, nor do they win awards, so likely use simpler/proven systems and sometimes the (simpler) components of the system are homemade to reduce costs. Although this business model exists, these farmers are likely to be better off forming or becoming part of a cooperation with other farmers in the area if possible to collectively reduce costs, since processing a high quantity of manure is needed to cover the costs.

Important to point out is that for the above business models a 'large' firm/cooperation is one that can process manure of most farms within a roughly 20 km radius and in the case of also fermenting to biogas, slightly larger. Huge installations that serve the entire country or multiple provinces are generally not feasible due to excessive transportation costs of raw high water content manure.

7.2.2 Equipment producers

Both of the identified business models below have some commonality with their focus being on developing technology. The Dutch manure processing market is (currently) limited and/or reaching a point of saturation in the Netherlands, so they may look towards other regions and/or technologies to expand to. Generally speaking, the equipment producers work with multiple suppliers, since they do not develop everything in house (it seems the market is not large enough to be able to afford a high level of vertical integration). Taking partial ownership of the installation they make is often also offered to reduce initial costs for the buyers and give lasting revenue streams for the equipment producers.

a. Broad Producers: These equipment producers focus on offering something for (almost) every step of the manure processing system. They may not offer the best component for each step of the process, but each step does work well with each other to form an overall good working system that is hassle-free for the customer. To an extent these can also be more of a design/execution firm than an actual equipment producing firm, especially since equipment, parts and even the final system is

often made using (help from) contractors or outside sources. Also, due to their broad knowledge, yet limited market in the Netherlands, these firms are more likely offer technologies for different industries and countries.

b. Narrow/specialised Producers: These firms are more focused on creating the best product for one (or a few) parts of the process. Although they may offer turn-key solutions just like the broad producers, their main profits are likely to come from their specific (specialised) part and the other parts of the turn-key system are likely sold 'at-cost' or at a lower profit margin. Logically, these narrow producers tend to produce their specific product in-house and use fewer contractors (at least for their step of the process), and also since they are specialised in their step they may be more likely to offer a maintenance or service plan for their specialised product, something which the broad producers sometimes do not offer due to having an international market.

7.2.3 Alternative business models/indicators

The identified business models were split up into manure processors and equipment producers, but it is also possible that one firm is capable of both. In such a case, the processing side and equipment producing side of the firm can be seen as separate but still within the same firm and in essence any combination of business models is possible. In several cases the manure processing firms were also a manure transportation firm themselves, which eliminates the need for intermediaries and is a form of vertical integration (reducing costs as there is no 'middle man' to transport manure). However, it should be noted that the participant sample size is too small to say this with full confidence.

Also, at the beginning of this research it was speculated by the author that perhaps certain technologies are more prevalent for certain business models or that there are a link between these (for firms that process the thick and thin fraction). However, for firms that process the thick and thin fraction that ended up not being the case, or at the very least, there was no distinct noticeable effect. A possible explanation may be that due to the relatively small market, the chosen technology might be based more on the reputation and relationship of the equipment seller, specific pricing (which varies more significantly in a small market) and experience of the one setting up the installation rather than the raw performance (or price-performance ratio) of the technology. This may eventually change in the future if the market grows and competition increases. However, what can be said is that firms with more complex technological processes (such as firm 7, who not only ferments manure into biogas, but also further separates the mineral concentrate into two substances) do tend to have a larger size and may be more long-term oriented, which is important to keep in mind when making a business case.

Furthermore, some biogas firms showed some peculiar behaviour. Two firms who deal mostly in biogas production from organic waste who were contacted via email responded saying they do not (or no longer) use manure to make biogas. One said they do not wish to be associated with manure processing and the other said they do not want to process manure. The reason for this is unknown, but one possible explanation could be that it is somehow less profitable or more difficult to process/ferment manure compared to other organic waste. This is interesting, as one participant that did use manure for biogas mentioned it is the way to go in combination with mineral concentrates (I4) and another participant is strongly looking into it due to the potentially high profitability relative to other forms of manure processing (I3). Meanwhile, firm 7 who will

also produces biogas did not comment on this. This potential disagreement with large biogas firms might be due to the fact that the manure processing industry is a (very) low-profit industry, and although biogas from manure may have a relatively low profitability compared to biogas from other organic waste, biogas from manure may still be more profitable compared to alternative forms of manure processing. However, this would require further investigation.

Also, up to now it has not been mentioned, but many successful manure processing firms are in the south of the Netherlands and (almost) all that were interviewed were in the south as seen in figure 7.2. This is likely due to the export requirements of the thick fraction to France (the 'mestverwerkingsplicht') being heaviest in the south of the Netherlands. Since 2017 (and still the same in 2022), the south part of the Netherlands is required to export 59%, the east 52% and the rest only 10% (Rijksdienst voor Ondernemend Nederland, 2022). Not only that, the south of the Netherlands is significantly closer to France than the North, meaning lower transportation costs, which is important for an industry where profit margins are small and several interviewed firms even lose money on the export part despite being close by [I1]. These may not necessarily be indicators on their own but it does show that regulations and costs (and revenues) play a big role. However, one participant also simply noted that there is plenty of manure to go around in the south-east of the Netherlands, which may also play a role, indicating there might be a higher concentration of livestock in that area [I6]. Firm 7 agrees noting that (livestock-related) agriculture is more intense in the south than in their region (they are the easternmost firm, by Hengelo).

Figure 7.2: Map with locations of participants (adapted from Google Maps).
Note that the one anonymous firm is roughly located in the south-east of the Netherlands.

7.2.4 Comparing business models to literature

The identified business models can be reflected against the business models from the literature review. One of these is from Bocken et al. (2014) who developed and proposed 8 sustainable archetypes, spread over 3 groups: technological, social and organisational. Here, within the technological group, the 'create value from waste' archetype was most relevant, and as speculated during the literature review, most firms in the industry fit in here, focusing on the circular economy and reusing/recycling manure.

However, what was not speculated or predicted is that the 'repurpose for society/environment' archetype within the organisational group would be present. Within that archetype, alternative ownership, cooperatives and 'not for profits' are included and this definitely returns in the identified business models, as the cooperative business model tends to be group-run and act 'not for profit' and other firms do offer alternative ownership (partial ownership as a form of payment).

The source from Donner et al. (2020) covered in the literature review also has some similarities. There, 6 business model typologies were proposed for 3 types of agro-waste (manure, co-products from cereals and co-products from wines, all combined) and 4 of them return in this paper in one way or another.

First, the 'upcycling entrepreneurship' typology, which is about innovative ways to valorise and convert low value materials/waste to high value, returns in the form of the manure equipment producers, as they continuously try to innovate and improve their system. However, they did not make the distinction within the group as this paper does.

Secondly, the 'agricultural cooperative' also returns, having a similar description to what was identified in this paper; an association of united people having a jointly owned firm to meet a common need (to process manure). This typology definitely overlaps with the similarly named business model identified in this paper.

Thirdly, the 'biogas plant' typology. As noted earlier, pure biogas firms had shown strange behaviour and did not want to be part of the manure processing industry, so they were not identified as their own business model in this paper. However, the fact that it returns as its own typology in Donner's paper does at least somewhat confirm the findings of this paper that pure biogas firms may be in some sort of bubble of their own. However, this would require further investigation.

Next, the 'environmental bio-refinery' was seen as well during this paper, but it was not identified as its own business model. This typology by definition is an integrated system to process by-products and residues (waste) to produce fuels, feed, materials and power. This coincides with firm 7 (Twence) which is a largely government owned waste processing plant. Essentially firm 7 is a manure processing plant which has a much broader scope to also process others types of waste, which results it in being a whole 'bio-refinery', but with this thesis only focusing on the manure processing part, the bio-refinery is outside the scope at the moment. However, just like with the biogas plants, this can be a good point of future investigation.

Finally, taking a more holistic approach, the typologies from Donner et al. (2020) generally appear to focus on larger firms or installations, including agroparks, whole bio-refineries, cooperatives (which typically are large) and supporting structures (which typically does not exist for just a small firm).

This on its own also says something, as the lack of mentioning any smaller forms of typologies could indicate it being less present or perhaps even less useful. This would then coincide with the idea that smaller installations are likely to be less successful, but at the end of the day, this is purely speculation and further investigation is needed to confirm this.

7.3 Patterns and links between MLP, SNM and business models

This subsection will look at how the MLP and SNM are connected to business models in a broad sense. In chapter 5 and 6 a lot of specific in-depth links have been made between the MLP and SNM aspects and specific business choices, but the aim of this subchapter is to come with a more general connection and/or reasoning for the analytical framework in order to be able to update it and give new insights for the future.

7.3.1 Links between MLP and business models

Landscape developments: Within the MLP, at first thought broad landscape developments do not have a direct impact on business models. This is because although changing views and increasing awareness of climate change did create a 'call for action' which initiated some of the participants to start in the manure processing industry, this 'call' doesn't define the business model (at least not for the participants). However, landscape developments do actually affect business models in a different way. Climate change and related issues are long term and will not be resolved quickly and as such, business models that focus on long-term solutions with long ROIs are feasible. Logically then, even other landscape factors such as political (in)stability will have an effect on business models. For example, if a country is unstable a firm may go for a business model focusing on short-term profitability at potential higher long-term costs since they may not be certain if they can continue with their business in the future. Thus, there is definitely a link between landscape factors and defining the business model.

Regime rules: The landscape developments also put pressure on and affect the regime level, as frequently noted in literature, but the regime level also has a direct effect on business models and their formation. Most notably, and as mentioned many a time during this paper, the rules and resulting subsidies have a huge effect on business models. As pointed out by a couple of participants, the current rules promote business models focused around exporting manure rather than increasing the value of the final product [I5, I8], meaning that the core focus and all resulting activities are different. Similarly, the subsidies allow for larger and more expensive projects that would not be possible before and thus strategies are sometimes specifically catered to take advantage of that. Thus, rules definitely have a large effect on business models as well.

Technology fit: However, the regime's effect on business models is not limited to rules. The technology fit regime factor also affects business models. The infrastructure and associated costs, which is part of the technology fit regime, can be a limiting factor as noted by several participants [I2, I5]. As such, it directly affects where your business is located and how large it can be, which in turn also affects how much manure you process, if you offer it as a service to others, what technology you use and your future business expansion opportunities.

Social network: Likewise, the social network of actors affects business models too. Whatever business model is chosen needs to satisfy the needs of many stakeholders. With different stakeholders holding different interests and powers (and to varying degrees), the business model would be different to satisfy these needs. For example, a strong eco-conscious movement, public and/or government may make 'greener' business models more suitable and/or desired in some way. Even something as simple as how many competitors there are in the network of actors changes what is possible, since few competitors would mean you may be able to get away with higher costs, focusing on R&D and perfecting your product to gain or retain dominance, whereas high competition may lead to having a business model focus more on lowering costs and increasing volume to gain market share.

Even generally looking at the agricultural industry/regime as a whole, the industry is relatively stable since food and produce will always be needed by humanity. As such, it can be seen as a safe industry to enter, albeit a high volume, low profit one. Thus, that too affects business models, as the value proposition must be tailored specifically to this industry.

Altogether, the link between MLP and Business Models is that the MLP factors have a strong effect on how the business model of a firm is formed. It can even be seen as a foundation or prerequisite for the business model to form.

7.3.2 Links between SNM and business models

Shielding: This is the first aspect of SNM. As mentioned previously, the shielding is very closely related to the MLP factors, with the same regulations and governmental interventions creating active shielding for the industry. Thus, these regulations and their resulting shielding definitely have an impact on forming business models. Also, the social network aspect of the regime directly defines the incumbent players and their actions, which also defines the passive shielding (or in the manure processing industry's case; that there is no passive shielding). Thus one can say that shielding does have a strong effect on business models, but it is in the same (non-separate) way as the MLP factors; that it is a pre-requisite or foundation.

Nurturing - Networks: The nurturing aspect of SNM is a bit more broad, consisting of networks, learning and expectations. For networks, although during the interviews nobody noted that it directly had a big impact on their business model, it likely did have an effect for most participants. For example, one participant did not enjoy that subsidies could not be used effectively on the workplace and the many different parties trying to steer him away from his vision (an indication of a misalignment of networks) which led him to do many things on his own (without subsidies) and use as few outside people as possible [I5]. Meanwhile, other participants who get along well with a variety of people (good composition and alignment) could set up a cooperation and even contracts between farms to ensure manure is constantly processed [I1]. Thus, it can be said with a good level of confidence that the networks aspect of SNM does affect business models. However, it should be noted that this is at a slightly lower level than with the MLP factors. In both cases the basic business model idea of processing manure was already established via the MLP, but their networks nudged their business model in a slightly different direction. In other words, their business model foundation was already found, but their networks formed the details so to say. Furthermore, the composition and alignment is dependent on the current actors in the regime and their views, so just like with shielding, it is possible to link the network part of nurturing to the MLP factors.

Nurturing - expectations and learning: Meanwhile, expectations (both exogenous and endogenous) were closely related to learning. Even during interviews oftentimes when asked about expectations, the interviewee responded with confirming if they should talk about what they learnt. To an extent this is logical, as the manure processing industry is not always self-evident, despite many participants starting out as farmers [I2]. As such, the process of learning taught them what to expect from the technology and industry regarding perceived functionality, profitability, etc. Then these expectations in turn determine what direction they go with their business model. In essence the process of learning and what they learn did not change business models, but the resulting expectations did have an impact. Also, similarly to networks in SNM, the expectations help form and nudge the direction the business goes in rather than be a pre-requisite/foundation. A firm may learn about different technologies and have more or less perceived confidence in different technologies which slightly alters their business model, but as seen from the analysis of the interviewed firms, many firms ended up having a similar basic manure processing process (e.g. a mineral concentrate as final product), but the specific steps and specific technologies are slightly different (e.g. screw-press type manure separator versus a centrifugal separator).

One can even further extend this idea by adding networks to the mix to form a sequential concept. After all, the learning has to come from somewhere and oftentimes expertise is used within the field with several participants noting that they learn from others and that learning from others is important [I2, I5]. Thus, a sequence is made where who you know affects what you learn, which in turn affects your expectations, which in turn nudges and shapes your business model to be slightly different. This can also be seen by the fact that some participants are approached by firms offering solutions based on new technologies with questionable prospects. If a farmer blindly trusts these people or doesn't know any better, then their business model may end up looking very different, as they may have learned the wrong information and formed the wrong expectations. Thus, there is definitely an effect of learning (indirect) and expectations (direct) on business models, but by being well-informed and seeking advice the (negative) effect on business models can be reduced. In fact, there can even be a feedback loop where a firm's new expectations results in them seeking new connections for their network or new learning experiences.

Empowerment: Finally, there is the empowering stage of SNM. Earlier on it was mentioned that the manure processing industry has a stretch and transform way of empowerment. After all, the changes in law made the industry possible in the first place and it is also what will (hopefully) empower it in the future as regulation changes make it more feasible. However, with slow transitions and an uncertain future, although stretch and transform is what is *needed* to empower the industry as identified by many participants [I1, I2, I4, I5], what is *actually happening* currently to some firms is that business models are fitting and conforming to the current rules and regime. With this in mind, some firms have more flexibility built into their business model as a core value, which should help them with an eventual (more rapid) stretch and transform empowerment phase once changes in law are implemented by the government. Thus, they can act fast once a beneficial change is made for the industry. Meanwhile, others have acquired broad knowledge for multiple industries or to process manure to multiple high-value substances, stating that is the way to go, which would also make them less dependent and less affected by government decisions. This would then be a more fit and conform approach.

In essence one can say that the industry and its factors is nudging firms to not put all their eggs in one basket to reduce risk for an uncertain future. They are being nudged to fit and conform to current regime factors while staying open and flexible enough to take advantage of an eventual empowerment phase, but it varies per firm and it seems every firm has a slightly different idea of what the future may hold. Yet others have no concrete firm yet and choose to trust and rely on government promises that there will be a change in laws, and have a business model focused on capturing such an empowerment phase when it comes.

Thus, whatever type of empowerment the firm thinks will happen does affect the firm's business model. However, it is not its own separate thing, relying on expectations. Thus it also relies on the previous SNM stages and even the MLP factors, like with Shielding. Because of this it can also be argued that since the empowerment relies on all these other factors that it is in fact those factors that cause the business model change rather than the empowerment, with the argument that correlation does not equal causation. After all, their preparation and expectations for the future is based on the previous factors. However, to go so deep into specifics would yield enough content for its own paper, and with the limited data set it would be difficult to prove with any reasonable confidence, so it will not be elaborated on further.

7.3.3 Overview and new alternative analytical framework

Taking all the links between MLP, SNM and business models, it is possible to create an updated and alternative framework than what was presented in figure 3.1, which can be seen in figure 7.3.

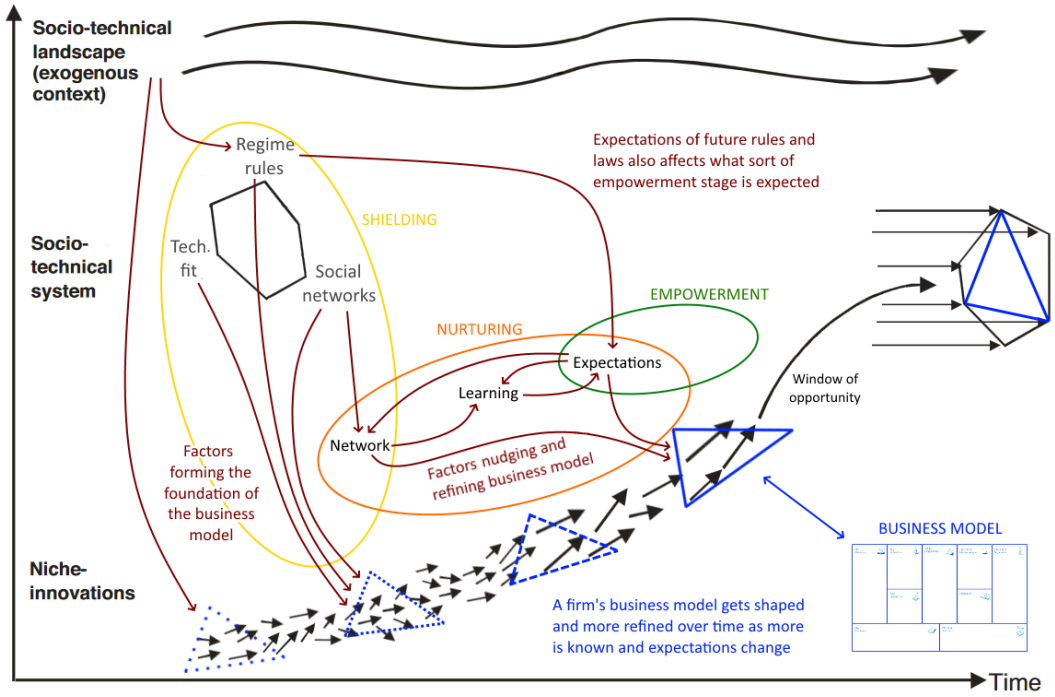

Figure 7.3: Alternative framework showing the link between MLP, SNM and business models specific to the Dutch manure processing niche (adapted from Geels (2019))

In figure 7.3 the relationship is kept relatively simple, showing that with every stage of SNM, the business model gets more developed and more refined with some factors having more of a clear effect than other factors. The basic landscape factors and regime rules (which also form the shielding of the industry) create the foundation for the business model and as time goes on, networks are formed, new things are learned and expectations change, which further form and shape the business model. Similar to making a clay vase where with time and experience you form your pottery better. This can also be seen from the participants as there are clear commonalities between all firms, but every firm's experience puts a slightly different twist on their business model (see figure 7.1).

Using this alternative framework, it is also possible to take a reverse view: if you are a newly starting firm you can take your planned business model and back-trace it in the diagram to see which factors are important to focus on or to see if something has been missed out. For example, a newly starting firm may have a great technical value proposition on paper, but back-tracing the framework would show that it is important to check your expectations and to make sure your business model is compatible with what you expect of the empowerment phase.

Another useful point related to planning and checking your business model is that it is clear from figure 7.3 that the networks aspect acts almost like a gate. In some way or another, who you bring in into your own network from the regime has a big effect on what you learn and what your expectations are, which in turn affects your business model. This is a trend that will return later on during the recommendations for newly starting firms section, because quite a few of the recommendations are about going for a trustworthy supplier, getting advice and being well-informed from others, and being sceptical of unproven technologies and firms.

Eventually it would even be possible to make a similar diagram, but separately for each of the 9 business model aspects. In this paper it was decided against since with only 8 interviews it is not possible to properly justify that many and specific trends. The same can be said for if more regime factors were employed, but the ones that were excluded can already be reasoned as likely not having as big of an effect on business models (E.g. culture).

7.3.4 Links between business models and MLP/SNM

In this part the idea is changed around. Instead of looking at the MLP/SNM factors and seeing how it has an effect on business models in order to make a new MLP/SNM framework, the opposite is done here: looking at how business models affect the MLP/SNM in order to try and make an updated business model framework. To find good links here is going to be difficult, since in this whole paper the MLP/SNM to business model direction was taken and the reverse direction has not been investigated. Nonetheless, there are still useful things to point out.

To start off with, when taking the BMC from Osterwalder and Pigneur (2010) and how it was filled in for the participants, it became clear that certain aspects were more important and emphasised than other aspects. For example, the 3 customer related aspects (relationships, segments and channels) ended up being less important and could be replaced with a much simpler single "customers" or "customer acquisition and retention" section. This is because in many cases the customers, relationships and communication methods were relatively consistent between the participants and as one said, it's a unique world where everyone sort of already knows each other.

Meanwhile, the partners aspect ended up being very important and was emphasised by the outcome of the alternative framework, even if many had similar types of partners. Which specific partners you choose can have an effect on your knowledge and expectations and these are also affected by other outside factors (news, general views, etc.). Additionally, while interviewing and asking about the partners, not every partner had similar levels of collaboration and participants did not always work with their different partners in the same way. Thus, perhaps it would be useful to add another section to the BMC related to how they communicate and collaborate with partners. This would then still be in the top-left (red) quadrant, since it has an effect on what knowledge and expertise you develop, which are some of the key points listed under "resources".

Speaking of which, the resources aspect is also important, although many firms had the same points to list there, with some form of knowledge/experience and some form of production or processing capability. Because of that, it is not necessary to analyse in detail, but it is still important. Similarly simple yet important is the key activities aspect. Whether a firm processes manure or makes the machinery has a big impact on the rest of the business model, so although it is straightforward in many cases, it is still important to keep.

Meanwhile, the cost structure and revenue streams, although basic and similar for a lot of participants, is still important and crucial for any business, and the differences that were observed ended up being important for the differences in business models, so it will be kept. In a similar manner, the value proposition is the point where many participants tried to differentiate themselves, mainly by offering greater quality products and/or services, so being an important and well-suited aspect, it will also be kept. The updated alternative BMC specific to the Dutch manure processing niche can be found in figure 7.4.

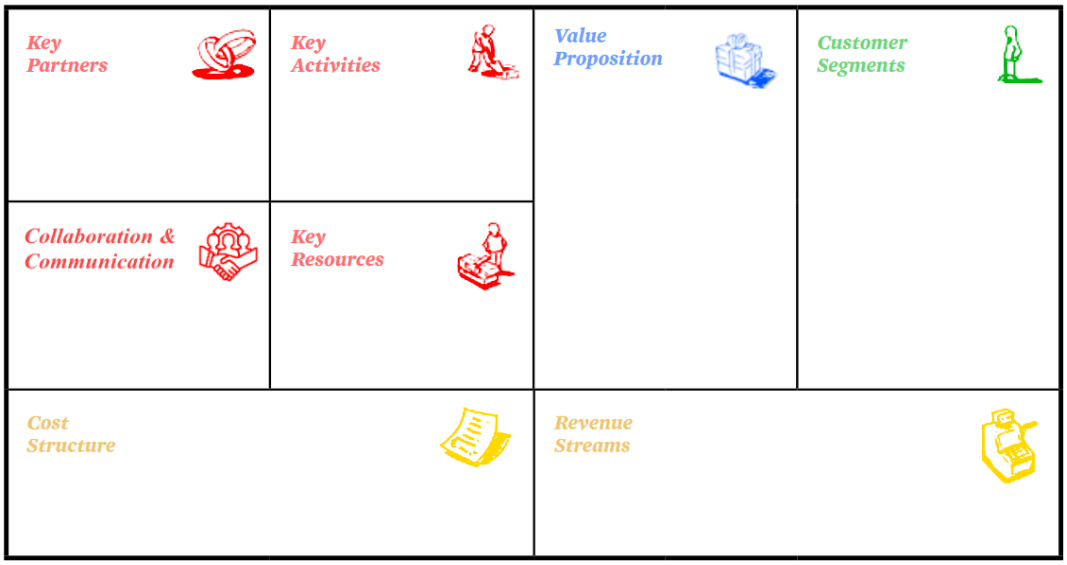

Figure 7.4: Alternative updated BMC specific to the Dutch manure processing niche (adapted from Osterwalder and Pigneur (2010))

7.4 Barriers and opportunities of the industry

Before one can make recommendations for newly starting firms in the final chapter, it is useful to lay out the foundation of the industry itself. In essence this is for the newly starting firm to decide if they want to enter the industry in the first place or to see if their planned business model matches the industry. For this, the barriers and opportunities are listed in table 7.1, which is an accumulation of all data so far.

Table 7.1: Barriers and opportunities for the manure processing niche

OPPORTUNITIES	BARRIERS
+ Very large manure market to tap into if laws/regulations support it + Large quantity of financing and subsidy options available from the government + Basic technology has been proven to work + Generally open industry → you can approach and talk to practically anyone + Sustainability focused industry → will stay relevant in some way + Easier to start out if you already have a farm and relevant knowledge	- Difficult and lengthy process to gain and update permits - Local municipalities not always supportive - Uncertain regulations and laws in the future - Uncertain if the uniquely high manure price will stay if farms/livestock are bought out - Low profit margins and long ROI period - Currently a limited (and possibly saturated) market for equipment producers - No easy/formal way of acquiring and accessing information from others - The complexity and knowledge required for manure processing is easily underestimated
NEUTRAL POINTS	
± Acquiring subsidies was easy for some, but difficult for others ± Overlap with water processing industry, but not much else → Some transfer of knowledge possible, but also not that many markets to transfer to	

To sum up the general feeling of the industry, farmers and firms are willing to process manure, and there are many people working on it and supporting the industry, with a new product for a new sector that can make a huge difference to a pressing issue with seemingly very few technical and environmental downsides, but the uncertainty caused by the government and its regulations, the lack of recognition of mineral concentrates and with no clear direction where the industry will go in the future is putting many off from entering the industry [I4, I5, I7].

8 Discussion

8.1 Discussing the results

Overall, the results were logical and clear although by no means trivial or insignificant. Because of the relatively low number of participants, some of the results and insights came from only one or two participants, which means that it was difficult to judge how important some of the points were, but even these insights followed clear reasoning. However, as mentioned in the methodology and later on in the limitations, the respondents themselves do have an influence, since different respondents would have different views and thus different points to mention and conclusions to draw. Thus, perhaps not all points that are out there are necessarily found.

Interestingly, some of the outcomes of the interviews were conflicting with each other. For example, most participants say it is a good idea to make as much use of the subsidies as possible, but one participant said that it is better to not use them. However, when taking into account the backgrounds and specific situations of the participants, even these counter-intuitive results make sense. After all, every firm is unique and every choice has its reasoning attached to it. Where possible, the reasoning was mentioned in the previous chapters of this paper. For the final recommendations of this paper (see next chapter) though, care was taken to normalize and take out any specific backgrounds or situations to make the recommendations more generalizable to newly starting firms, since the specific background of the new firms is not known.

Speaking of the final (business model) recommendations, they and the insights that lead to them originated from multiple places and more than one technique was used:

1. Asking the firm if they have insights or recommendations to newly starting firms.
2. Looking at the commonalities between successful firms to see if there is a trend for success that can be copied by newly starting firms.
3. Looking at the industry to extract valuable points to keep in mind for creating and improving their business model.

This ensured that multiple viewpoints were taken into consideration and eventually some of the insights were only possible because the author had an outside view of all the different firms. For example, each individual firm may think they are alone or inefficient in exporting their phosphate rich thick-fraction and are thus losing money on it, but only by looking at all the firms can one really say that it is normal for the industry and that the other parts of the process need to cover this cost.

However, besides having an outside view of the firms, this research was also done out of the blue by people not from the industry, giving it an entirely 'outside the industry' view. On the one hand, this means that the author has relatively little specialised expertise of the industry and that could lead to some aspects being overlooked, but on the other hand, as one participant pointed out, it can also be seen as having a fresh outside view, which on its own can give new insights as it is not bound or influenced by current thoughts, trends and habits.

In terms of validity, a lot of the results and insights came directly from large players in the industry, meaning that they come directly from the source. For these it is reasonable to say that the validity is fairly high. Even the insights that were derived from looking at the commonalities between participants and by looking at the industry can be considered as fairly valid since in practically every case there was a logical link with logical reasoning. However, one possible point of criticism is that the insights coming from participants come from well-established players that likely follow the same formula for success as they did many years ago. If the industry changes significantly, the insights and eventual recommendations may also have to change, so to an extend one can criticise the results as not being as valid for the future.

Another interesting point to mention is that manure processing can be translated in Dutch to either 'mestVERwerken' or 'mestBEwerken' which was pointed out by a few of the participants. 'mestVERwerken' is what is legally defined by the government to end up in a dry and export-worthy substance, whereas 'mestBEwerken' is about extracting the value and the nutrients, but does not follow any specific laws yet (DLV Advies & Resultaat, 2021). When contacting firms and sending documents in Dutch the word 'mestVERwerken' was used, but fortunately this was clarified during the interviews for the participants that made the distinction and quite a few participants saw both as synonymous, often referring to both types as 'mestVERwerken' on their website too. However, due to this wording and legal difference the focus for firms does lie more on reducing volumes and exporting rather than extracting value (Verdoes et al., 2021), as seen before in this paper.

8.1.1 Discussing the Frameworks

The chosen framework to answer the research questions consisting of the MLP, SNM and business models was good overall and the author is happy with the outcome. The socio-technical landscape and regime were used and aided in making business model recommendations. Although the frameworks themselves may not have appeared directly often during the recommendations and outcome of this paper, they were necessary to reach the recommendations and back them up. For this, in literature the MLP and SNM appeared to be the best for analysing the niche and to the extent of the author's knowledge it still is very suitable for this paper.

Within the MLP, the choice was made to narrow down the socio-technical regime to just 3 factors. In hindsight this was still a good idea. Industry, infrastructure and technology was combined into technological fit, policy was kept as is and the markets and users part was kept as social networks. This ended up being a good choice, since policy (rules) on its own had a lot of responses and the whole technological fit had the industry, infrastructure and technology intertwined in many cases. Separating them would likely not add to the discussion or analysis. Similarly, the cultural aspect of the socio-technical regime was excluded altogether and although no data was gathered on this, it appears to still not be a problem. After all, the topic of this thesis is on emission reduction and helping firms succeed, which is generally independent of cultural differences. The only exception to this is that the general Dutch work culture may have an effect, because one participant informally noted that Dutch employees are more likely to share knowledge than international employees. However, this should still not be a problem since the entire thesis is on the Dutch market with Dutch firms and Dutch employees, so it is consistent.

The SNM aspects were kept as-is from literature and fitted well in this paper. One noteworthy point though is that within SNM the shaping of expectations and the iterative learning aspects of nurturing were distinctly separate. However, in this paper they ended up having a lot of overlap. During the interviews the questions of "what are your expectations?" and "what did you learn?" often had similar or interchangeable responses and sometimes the participant even interpreted what their expectations were as what they learned. Although clarification was often given during the interview that they were separate points, if the interviews were to be redone, this distinction would have to be clearer. However, one could also argue that it reinforces the observable trend that most expectations were formed and created by learning.

This was eventually also one of the aspects that was shown in the alternative framework proposed in chapter 7. The alternative framework, which shows the effect of the MLP and SNM factors on business models, is mostly separate from the rest of the results. One of the key points that was discovered was that networks act like a gate or enabler that subsequently affects your learning, expectations and business models. Since the conclusion from this is a bit more drastic and 'out there' than the business model recommendations and insights that were made throughout this paper, and since the links are somewhat less clear, the validity of the alternative framework and its conclusions is almost certainly lower. As such, it should be taken with a grain of salt and would require further investigation. However, despite this, the findings still appear to be logical and it does follow the trends and patterns from the rest of this paper, so there may be some truth behind it. Something similar can also be said for the proposed alternative BMC specific to the manure processing niche. From the findings, it also appears to be a logical step forward for analysing business models in this specific niche, but it should be taken with a grain of salt since it is not 'proven' yet so to say.

8.1.2 A helicopter view of the future of manure processing

As was mentioned many times during this paper, the future of the manure processing niche is still very uncertain, especially with relation to the laws and regulations. However, discussing the future of the industry in detail would be enough for its own thesis (e.g. identifying and analysing scenarios). In fact, during the interviews it was even mentioned by one participant [I8] that some possible scenarios have already been formally hypothesised in papers (Nederlands Centrum Mestverwaarding, 2021). Nonetheless, it is still a good idea to very briefly discuss this, especially since with the current conservative views of the interviewed actors the future according to this paper so far is looking a bit grim, even though this may not be the case in the future.

Currently the leaders in the industry are relatively low tech and the current leaders have risen up at a time when regulations and laws were simpler. Being fairly conservative, they continue with their current systems to try and improve them, mostly incrementally. As one of the participants informally noted after the interview, these people in the industry tend to look at their 20 to 30 years of past experience, but may not always be looking at future changes, yet they need to be prepared for new societal developments since some form of market and technological disruption is likely to happen [I3]. For this, thought leaders and pioneers in the industry are needed and these can come in the form of new entrants who do not necessarily have the same conservative views.

Also, on the topic of regulations, during a webinar from January 2022, one of the spokespersons for agriculture from the house of representatives ('Tweede Kamer') Thom van Campen mentioned

that they see and acknowledge the uncertainty in the industry and that rules are always lagging behind innovation, but that there are now also new motions to change the generic policy into a goal-oriented policy which should help out the manure processing industry (De Boer aan het Roer, 2022). Although certainty or a positive future is still not guaranteed, current and newly starting firms in the industry should not lose hope. A window of opportunity may still open up with new regulations or perhaps even a new technology, allowing the manure processing industry to transition and grow. After all, implementing manure processing technology is arguably a better solution than reducing the number of livestock to reduce emissions.

However, that does lead to the question of how does one go with the transition or what do farmers need to do in order to go with the transition? The conservative views of many of the participants mean that some of the insights are not necessarily focused on going with the transition, despite it being very important. However, the actions you need to take to go with the transition heavily depends on what sort of transition happens and with all the uncertainty it is difficult to prepare and give solid pointers for the transition. Nonetheless, some general pointers can be given such as staying open to new (technological) developments and being relatively flexible to change, but these do go against some of the points mentioned by participants. Therefore, it is difficult to make good recommendations for transitions as there is always risk associated with uncertainty, but this is still a good point for future investigation.

8.2 Limitations of this research

Although the results were logical and the findings were good, this research is not without its drawbacks. These will be discussed here in no particular order.

One drawback is that as it turned out, the topic of manure processing is often seen as a farmers versus government debate (at least according to the interviewed participants). With this knowledge and hindsight of how important the government is, it would have been useful to also interview government personnel to check both sides of the story. With only the farmer's side investigated in this report it is looking strongly like the government is the limiting factor, but in reality this may not be the case. Thus, one can consider the views of this paper as biased.

Also, only (seemingly) successful firms were interviewed, which might affect the analysis. For example, it was noted as part of the business models that trust was important for relationships for all firms. This does not necessarily mean that all firms in the industry rely on trust or are trustworthy, but rather that only trustworthy firms ended up being successful. However, for the intention of this paper, to help newly starting firms, if they imitate the successful firm's behaviour, it will likely still help them out, so that the participants are biased may not be a bad thing.

Along similar lines, some data might be missing. Unsuccessful firms have not been interviewed, but will very likely also have useful points to mention, because they might know more of what *not* to do. If unsuccessful firms were also included, then the outcome of this paper may have been different and other conclusions could have been drawn. However, the decision was made to only look at successful firms so that the analysis of what a firms should do is stronger, plus, it would prevent the analysis from becoming too wide, as with the already low number of participants it would be more difficult to definitively identify differences between successful and unsuccessful firms.

Furthermore, this paper assumes that large manure processing firms that have survived for a longer period of time are successful, but in reality this is not necessarily the case. Although successful firms do become large and last a long time, the reverse is not always true. It is possible for a barely successful firm to still become large and last a long time, even if they are only barely holding on.

With this in mind, one somewhat larger downside of this paper is that no actual financial data or numbers were asked from participants. Because of this, it is not possible to say if one firm or business model is more successful than another firm or business model. Instead, it is only possible to come up with reasons *why* and *how* the interviewed firms were more successful than other firms which have since exited the market or gone bankrupt. Although it would theoretically be possible to ask participants for their financial data, not only would it likely be difficult to standardise across the different formats, sizes and included content, the participants would be less likely to take part in the study since particularly sensitive data is taken from the firm. Considering the number of participants was already less than ideal, this would not have been a good idea in this paper.

Related to the participants, the response rate was less than ideal. Originally the plan was to have 10 (or more) interviews, but it ended up only being 8. This means that there are fewer interview sources to back up claims of other participants, making it a bit more difficult to confirm some of the points that were made by participants. Also, as mentioned during the methodology, the respondents can have a major influence on the outcome of the paper since different respondents may mention different points, resulting in a different analysis. Since there were relatively few respondents in total, it means that even just one different respondent can have a big influence and it also means that there may be insights out there that have not been discovered. Although the outright low quantity of participants in itself should not have too much of an effect on the outcome of this paper, it will be difficult to judge how much of an influence different participants and their variability would have. After all, if the players in the niche are homogeneous, it would not have a big influence, but if they all have different views it will have a big influence.

Next, time is also a limiting factor. More time would allow for a longer interview period and thus more data could be gathered. Moreover, gathering the data took (considerably) longer than expected. Not only did the process of getting the interviews approved take quite some time, the responses came in slowly and the winter break meant that the last few interviews were postponed to 2022. This meant that it might be possible that more trends and insights could be made if one were to put their head to it for longer, but the major insights have been observed.

Another bias is volunteer bias, which is a form of response bias, because all the results come from participants that actually responded to the emails and agreed to be interviewed. The participants that respond and have been interviewed may have different traits from those that did not respond. This may be a problem, because (for example) one key recommendation from this paper is that it is good to be open and share knowledge and experience, but it could also be that people who agree to interviews are just more open by nature. Thus, it could be that more of the industry is closed, but those just do not respond to the emails nor want to partake in interviews. It is difficult to judge to what extent this has an effect on this paper, but it should certainly be kept in mind.

Other forms of bias should not have a significant effect. For example, question-order bias or confirmation bias should not have a big effect in this case. After all, the questions were non-leading questions and participants were allowed to answer however they liked. Also, the order did not matter either, since a lot of the questions could be answered independently and thus could be changed around without a problem. On top of that, the participants got the questions by email beforehand, so they had time to look at them before the interview. Similarly, interpretation bias should also not be present to a significant extent. All interviews were recorded and transcribed word for word and afterwards a document of notes was made based on the transcription within a day or two. All noted points were noted down in a literal sense and as objectively as possible, meaning that almost every point made in this paper that was based off of the interviews can be traced back to sentences or phrases said by the participants.

Finally, purely the nature of this paper brings its own limitations. By having a small number of detailed interviews you get a lot of new insights, but to properly prove these insights, a lot more data is needed to confirm it. Thus, although there are many insights (being an exploratory paper), quite a few of the trends and patterns identified may rely on only 2 or 3 interviews, which means the more specific results need to be taken with a grain of salt. However, the broader results, namely the ones where many participants agreed on (e.g. regulation changes are needed), can be regarded as relatively safe trends to assume.

8.3 Academic/scientific contribution and relevance

8.3.1 Manure-related research

The academic contribution of this paper largely relies around it being a novel and exploratory piece of research. To the extent of the author's knowledge, this is the first paper on business model recommendations for the manure processing niche. Being the first of its kind, there are some pros and cons. For example, there are a lot of new insights and a lot of the points that were found are very applicable and useful to new firms. However, being the first paper, the nature is exploratory rather than explanatory, meaning that the 'why' may not always have been found or completely justified. In such a sense, this research is also rather broad, but that also means there are a lot of direction to go to for further research (as will be discussed at the end of the conclusion chapter).

When looking at other academic papers, there are quite a few papers on the technical and financial feasibility and analysing the environmental impact of the manure processing niche and its technologies. However, this paper does not contribute to that part of the manure processing niche literature. Instead, it leaves that part of the literature alone and breaks off to contribute a new part, drawing a general picture of the niche, its players and the factors affecting the industry. Such a broad overview of analysing the manure processing niche, especially with respect to the MLP and SNM, did not exist up to this point, not to mention all the business model aspects. It does improve upon the business model typologies of Donner et al. (2020) by identifying more business models for the agro-waste industry, however, since there are very few other papers related to this research, this thesis is more its own stand-alone novel research from which future researchers can build upon.

8.3.2 General and framework-related research

Alternatively, one can also look at the scientific contribution from a more 'regular' non-manure perspective. In such a case this paper does still contribute to the literature. More specifically, the link between business models and the MLP/SNM was made and justified in this paper. Although this was previously mentioned in literature (for example, by Hakim (2021)), this paper offers new insights and a new perspective to the connection. For example, that the MLP can have a strong effect on or link with business models (acting almost like a prerequisite/foundation), whereas SNM has a smaller nudging effect that appears to start later on in the process. There was also the point of networks acting as a gate to the nurturing and empowerment phases of SNM, which eventually helps form a firm's business model, whereas shielding is largely defined by the socio-technical regime, at least, for the manure processing niche. Whether this is also true for other industries or in general would require an analysis of multiple industries, but that would be outside the scope of this paper. However, it does still show the relevance that other researchers can also use such an approach of linking different factors from different frameworks together and hopefully this paper inspires other researchers to do something similar and novel.

Furthermore, although this paper is predominantly an exploratory paper, by using the MLP, SNM and business model frameworks as literature describes it to be used and having it work out well, it shows that those frameworks are well-formulated and suited to analysing the industry. Thus, to a (small) extent, this paper can also be seen as a form of confirmatory research, supporting the effectiveness and usefulness of those frameworks, especially for the MLP created by Geels (2002 onwards) and SNM by Smith and Raven (2012). With this in mind, this paper can also be used as an example to back up and confirm their research, making it relevant for more than just identifying new links and patterns.

8.4 Practical/managerial contribution

8.4.1 For managers and players in the niche

As was briefly touched upon in subsection 1.4 when this research was first designed, this research is certainly relevant to managers within the niche and there are a lot of practical points take away from this paper. The manure processing industry really is a niche and not a particularly glamorous one, so it generally does not get all that much attention. Thus, as mentioned in the previous subsection, there aren't any papers on business models in the manure processing niche, meaning that a newly starting firm has nothing to go off from when entering the manure processing industry besides generic business model pointers.

Not only does this paper make the link between business models and the manure processing niche, the main goal of this paper was to offer recommendations to newly starting firms in this industry, which are shown in the next chapter. Thus, there is a lot of managerial relevance and contribution, helping out players in the industry. By using the concepts of the MLP and SNM in combination with business models, a stronger relationship can be made and more recommendations can be made than if the focus was on just business models alone. In fact, it may very well be possible that a newly starting firm does not know some of the recommendations or factors even existed or were significant if it were not for this paper. For example, networks playing a fundamental role in defining the

learning and expectations of a firm, which in turn drives and nudges their business models. Besides helping put emphasis on which points firms need to focus on, the barriers and opportunities of the industry as a whole was also presented, which further aids in the decision making of new firms.

8.4.2 Broader and societal relevance

However, besides helping the actors and firms processing manure themselves, there is also a broader practical relevance and contribution. Firstly, this paper will have an (indirect) impact on farmers in the agricultural industry that do not wish to process their own manure. By helping out the manure processing industry with the recommendations of this paper, those manure processing firms should become more successful. This in turn leads to not only more (successful) firms to process manure for regular uninvolved farmers, giving farmers more choices to easily resolve their manure problem, it would mean there are likely to be fewer unsuccessful firms for farmers to lose money on if they invest in them. In the long run this could even give farmers and the general agricultural industry more confidence in the manure processing industry, reinforcing the niche and potentially creating some form of positive feedback loop.

Secondly, it is relevant to the whole country and perhaps even the world. This is because there is a big nitrogen problem to solve; to save the environment's flora and fauna and to help preserve nature for generations to come. The reduced emissions and mineral capture from manure processing also has a whole multitude of (social) effects and benefits on its own, ranging from health benefits, to reduced political reliance on foreign fertilizers, to helping lower the speed of mineral leakage and dilution into the environment that may become a problem in the future. Even animal welfare is impacted by this, as processing manure immediately as it comes out of livestock means that animals won't need to stand in or above their own emissions, which may be unpleasant to them. In the future, the relevance may even expand much further than just the Netherlands as other countries become concerned about their emissions, and the manure processing niche is still a promising solution to this problem. Thus, it is safe to say that there is a tremendous practical relevance and contribution, which stretches out much further than just the firms in the niche.

9 Conclusion & Recommendations

9.1 Conclusion

To conclude, the research questions will be answered, starting with the sub-questions and then ending with the main research question.

RQ 1: *What is the current socio-technical regime and landscape and how does it affect the niche?*

This research question was all about identifying the outside forces and factors acting on and affecting the niche. For this the MLP was used, identifying aspects from the socio-technical regime and landscape factors.

Starting with larger macroeconomic landscape factors, climate change and awareness were one of the first things to be investigated, where society generally became more aware and wanted to do more to help the environment in recent years. However, this on its own did not greatly affect the industry. What did have a bigger effect though is the 2019 nitrogen crisis, where a lot of construction projects got halted and the lights got shined on the agricultural industry to reduce their nitrogen emitting manure, which may have pushed some recent developments of manure laws to change.

Moreover, the effect of the 2008 economic crisis and Covid-19 was investigated too, but these ended up not having a significant effect for most, especially since occasionally having a good or bad year is normal. What was also discovered during this research is that there is a global natural resource trend that does have an effect on the industry. Natural resources are becoming more scarce, with chemicals, natural gas and minerals all becoming more expensive. These generally helped out the manure processing industry, since their process outputs (products) become more profitable as conventional fertilizers become more expensive.

Diving into the socio-technical regime, first a stakeholder map was made of the industry. Here it became evident that for the manure processing industry, there are many stakeholders involved, but the most interaction is between the manure processors and the equipment producers, who tend to work closely together to comply with government regulations. The technological fit had some interesting points too, mainly related to infrastructure. There is more or less an ideal size for a manure processing installation; namely one that can process most manure in a 15-20 km radius, since smaller installations do not process enough manure to cover the cost and larger installations are burdened by excessive transportation costs, made worse by rising diesel prices.

Finally, laws and regulations were investigated, which ended up having a huge impact. There are quite a few laws, some of which haven't changed in over 30 years and which do not entirely facilitate the innovation and adoption of the manure processing niche. Moreover, acquiring permits is often a lengthy and difficult process and that laws and policies are uncertain in the future does not help with this. Fortunately, there is a tremendous amount of funding available for subsidies and the government acknowledges the difficulties, which does give hope, but some still fear that alternative measures (e.g. reducing livestock) may still hurt the manure processing industry.

RQ 2: *How do current niche firms capture the benefits or tackle the problems of the regime and landscape?*

This question is about how the players in the industry are taking on the challenges they face, using the 3 main aspects from SNM. The first of these, shielding, can be either passive or active. Passive shielding was not present, with a large agricultural market and many large players already existing, but active shielding was certainly present, since laws and regulations essentially formed the entire niche, allowing it to exist.

Next, the nurturing aspect of SNM is split into 3 parts too, with the first of these being the voicing and shaping of expectations. Regarding exogenous expectations, players in the industry generally expected a certain size to be successful, mineral prices to increase, subsidies to remain in substantial quantities, but most of all, that the industry can go in any direction still, with few participants agreeing on the exact direction. Regarding endogenous expectations, they generally expected new firms to encounter hurdles at the start, that it is best to not reinvent the wheel and that something proven is expected to work best, and that biogas could be promising in combination with mineral concentrates.

The second part of nurturing is the formation of networks. Here it was found that the manure processing niche is a unique world where there is no formal way of getting to know people, yet everyone somehow still sort of knows each other. It was also discovered that there are a lot of installations that do not work and a lot of firms that fail trying out things that have already been tried before, which shows that players are careful with their composition. Regarding alignment, players in the industry generally have the same ideas and are willing to cooperate, but ensuring commitment through (for example) contracts was also shown to be a good idea. However, the largest misalignment occurs between the manure processing niche and the government/municipalities, as they tend to distrust and dislike the manure processing industry, sometimes unjustified, but unfortunately there are indeed also a few players in the industry committing fraud which is making life difficult for the rest of the industry.

The third part of nurturing is the iterative learning process, and practical learning ended up being the most dominant form. In fact, many of the expectations were formed from what they learned, such as that it takes some time to perfect your process and that commitment is useful to keeping your capacity full and profitable. Many participants also sought learning from others and noted it to be very important, as manure is no easy substance. Interestingly, some participants also noted a key difference between the manure processing industry and larger, more professional industries, being that the latter generally has a different level of quality, refinement and education, which all also has an effect on how they run a business.

Finally, the last part of SNM is empowerment, where the industry is mostly following a stretch and transform approach, as the changing rules and regulations is what makes the industry more viable. However, a small amount of fit and conform empowerment was also noted as the change is happening very slow, so current players still need to fit and survive in the market.

RQ 3: *What sort of business models do firms in the niche currently use?*

In order to make recommendations to newly starting firms, especially when it comes to their business models, first the existing business models should be known. From literature it became clear that no pre-made business models would be used and instead new ones would be made. To do this, the business model of each participant was analysed via Osterwalder and Pigneur's (2010) 9 business model building blocks and the data aggregated to identify business models. This ended up with two rough groups of identified business models.

The first of these groups are the manure processors, where 3 types were identified: 1. the large one-owner installations, characterised by a large size operating in a region, having everything in their control, and generally greater flexibility and responsiveness, 2. the cooperation installations, characterised by a group of farmers coming together to collectively invest and reduce costs, and an emphasis on consistency and commitment, and 3. the small one-farm installations, characterised by their small size and lower likelihood to make a profit, by using generally simpler and proven systems and perhaps partially constructing their own equipment.

The second large group is the equipment producers, where 2 main types were identified: 1. the broad producers, characterised by trying to produce something for every step, having wide knowledge, and although not necessarily having the best individual equipment, they offer a good working overall system, and 2. the narrow/specialised producers, characterised by focusing on making and perfecting one step of the system, but may still offer turn-key solutions.

Interestingly, no matter what business model or even type of firm it was, there were quite a few commonalities between all firms. Most significantly, the majority of successful firms had a lot of partners and were willing to share and learn from each other, had a focus of offering a good quality system/product/service even if it may be slightly more expensive than the competition, and generally did not rely on any type of publicity other than simple word of mouth. Similarly interesting, the type of technology used did not have a noticeable impact on the business model, with the slight exception of fermentation for biogas, which requires a larger size to be feasible.

RQ 4: *What trends and patterns arise from the niche and their business models and what sort of (business model) recommendations can be made to newly starting firms in the niche?*

With the insights of the first 3 research questions, it is possible to find the trends and patterns. At the start of this thesis, it was not known what sort of trends and patterns would be found, but in the end there were definitely some discoveries to be made of the manure processing industry.

For example, links were laid between the MLP, SNM and business models. For the first of these, the link between the MLP and business models, it was found that landscape factors, regime rules, the technological fit and social networks all have an effect on business models, especially the regime rules. These act almost like a foundation stone or prerequisite to form the business model. Meanwhile, going a step further to the link between SNM and business models, shielding also has a foundation-like effect on business models, largely because the active shielding relies heavily on the regime rules. Within nurturing, the networks, expectations and learning aspects also have an effect on business models, but not all in a direct way. Who is in your network affects what you learn, which in turn

affects your expectations of the technology and industry, which in turn affects how you make your business model. This effect on business models is more a refinement and nudging of the base business model that a firm may have made before. All this is shown using a new alternative framework, which puts emphasis on the importance of having a good, reliable network in your firm.

Besides an alternative framework, an alternative BMC and some barriers and opportunities of the industry were also identified, which both should help newly starting firms on making business model decisions. Some of the largest barriers include low profitability and long ROI periods, municipalities and permits not often being supportive, and an uncertain future, whereas some key opportunities include a large manure market to tap into, plenty of available government funding and subsidies, and an environmentally focused topic that will stay relevant for the foreseeable future.

Finally, and arguably the *piece de resistance* of this paper, there are recommendations to be made to newly starting firms in the industry. These originate from asking the firms themselves, by looking at commonalities between successful firms and by looking at the industry as a whole. Although some of these have been mentioned before (briefly) in one way or another, they will be presented in their own separate recommendations subsection later on.

> ***RQ:*** *How is the manure processing and recycling niche in the Netherlands currently developing and how can business models help innovators in the niche succeed?*

Essentially the 4 sub-questions together already answer the main research question, but to quickly sum it up and take an eagle-eyed view, it can be answered as followed.

For the first part of how the niche is currently developing, it has been developing relatively slowly for the last 30 years with more rapid developments mostly occurring in the last 10 years as regulations have been updated and pressure was put on the agricultural industry to reduce emissions. On the one hand, this is putting some people off from entering the industry out of fear of losing a huge investment as the market is unstable and uncertain and since a lot of farmers just want to farm compliantly without any issues, but on the other hand, it is also attracting others to an industry with a lot of potential and a lot investment opportunities from the government, which will likely have some big changes occurring in the near future. No-one can quite say with certainty where the industry will be heading in the future, but nonetheless manure processing is looking like a viable option to reduce nitrogen emissions while keeping the farmers and the economy in business.

For the second part of the main research question, business models can certainly help innovators in the niche succeed. By looking at current successful players one can draw conclusions and insights to use for their own firm. Similarly, one can see what parts of either the BMC, the MLP and/or SNM they are strong and weak at and use that to build up and improve their business model using insights from this paper. In the end, out of the 5 total identified business models, there was no one clear 'best' business model, but there were definitely commonalities that a new entrant can copy and it is also clear that the focus should be on a generally large installation that is capable of processing most manure in a 15-20 km radius.

9.2 Recommendations for upcoming firms starting in the niche

In this subsections the final recommendations will be made that can be used by new firms starting in the manure processing industry. For this it has been split up into direct recommendations, which the participants explicitly mentioned and which will be handled first, and the recommendations that come from the analysis, which comes afterwards. Most of these recommendations are applicable to both the manure processors and the equipment producers.

Recommendations for those that are not starting out in the niche have not been made as it is outside the scope of this paper, but as was evident from the analysis, there is a fairly clear clash between the agricultural industry and the government/municipalities. From this, a very broad recommendation can also be made to the Dutch government to collaborate and communicate more with the agricultural industry to try and reduce the uncertainty and confusion and although this is happening already to an extent, more collaboration in the future can be beneficial.

9.2.1 Recommendations from participants

Go for something that is proven to work and is good quality: A lot of the successful participants noted that having a system that works and works well is very important [I4, I5, I6, I8]. It may be more expensive to go for in the beginning, but a good quality system should last longer and be more trouble free in the long run. Also, a good working, good quality system will allow you to give good quality assurance on the outputs, which is important since some parts of the industry does have a fraudulent taste to it [I8]. With this in mind, if you are a processor that is looking to purchase a system, make sure you also have a reliable supplier with reliable, good working technology [I4, I6]. There are quite a few players in the industry with unproven technology that ends up not working or consuming too much energy [I1, I6], or as one participant puts it; go for an installation that you've seen in at least 3 other places [I5].

Collaborate, share and learn: Everyone is looking for their own success and quite a lot of new players are tight-lipped about their technologies and systems, believing they have the next big thing. However, so much has already been tried before and so many have made the same mistakes that have already been made by others before, but all these failures could have been prevented if they just communicated and shared more [I2]. Thus, people need to collaborate and learn from each other more and seek advice from those that already have success in the industry [I2, I6]. After all, the manure processing industry is quite open and a lot of people are willing to collaborate, especially since there is plenty of manure to go around for everyone [I2]. This goes hand in hand with the previous recommendation of getting a good working system, because sometimes the technology producer doesn't know their system won't work, because they just are not communicating enough with others to discover the flaws.

Have a good launching customer: This is essential for pretty much any industry, but having a good, understanding launching customer will help kick-start your firm [I4]. A good launching customer will cooperate well, help aid in the successful implementation of your system (if you are an equipment producer) and give good publicity, but a bad one can do the opposite, ruin your reputation and possibly bankrupt your firm.

Commitment of manure supply: Manure processing systems are most profitable when running at full capacity, but to run at full capacity you need to have a steady supply of manure. Therefore, it is useful to have some form of commitment in the supply of manure beforehand by involving parties and getting their guarantee for their volume in advance, such as via contracts [I4]. It is possible to have a steady supply without formal commitment, but that is often only the case when your manure price is below market price, ensuring you will always have enough customers willing to use your service.

Use subsidies where possible: Try to take full advantage of all the innovation trajectories and subsidy schemes for innovative firms, because the industry is a low profit margin industry and every little bit helps [I4]. Generally speaking large firms are more aware of all the possible subsidies and investment opportunities available to them, but smaller firms (such as newly starting firms) may unbeknownst to them be missing out on these [I4]. This would be a shame, because the Dutch government is investing a huge amount of money into solving the nitrogen problem, and a significant portion trickles down via initiatives that new firms can apply for in one way or another.

Don't rely on the current (high) manure price: Although not everyone agrees on the direction where the industry is heading, there is a realistic chance that the manure price may drop in the future [I6]. Therefore, a new firm's focus should not be on the waste disposal fee (like most of the industry right now), but on the sales market of the outputs, whether it be the mineral concentrate, green gas or other substances [I8]. Essentially, one should extract as much value as possible from the outputs so that even if the manure price drops to zero that the outputs can cover the costs.

Communicate with locals: It is very useful to have a good discussion with and consideration for the locals and the local municipality, because you will get resistance [I8]. As mentioned previously, like with windmills, everyone agrees it should come, but nobody wants it in their backyard or wants to deal with the nuisance created by it [I7]. By communicating and trying to collaborate you can increase the chances of getting your permits approved than if you apply and nobody knows or trusts you yet.

Keep in mind the uncertainty: As noted by practically all participants in one way or another, one of the biggest things withholding the industry from growing according to them is the government and their regulations. The Dutch government has the right general idea to reduce emissions, but the execution of this idea seemingly keeps changing. The willingness to adopt manure processing technology is already large within the agricultural industry, but the uncertainty caused by the regulations/governments is causing insecurity for potential adopters [I4], since they do not know if their new installation will be a paperweight in a few years. Thus, keep this in mind and keep a close eye on regulation changes.

Look at the big picture: If you are a newly starting firm, look at the total picture. Everything in the industry is complexly linked together; technique, combination of inputs and outputs, networks, and (un)certainty with permits and manure [I7]. Thus do not just focus on one point (such as contracting to get manure in) since you may not be ready or able to handle it at another point (e.g. permits). It's about the whole story and you need every part of it to work well. Not only that, keep circularity and the future in mind, because not just emissions, but natural resources too will become more important in the future. Thus, plan accordingly.

If you want to become rich, do not go into this industry: This is a final recommendation given by a couple of participants, because there is not a lot of money to be earned in this industry, at least not currently [I5, I8]. After all, the prices are in the scale of euros per tonne, not euros per kg [I8]. Because of these low prices it is also useful to choose an appropriate technology for your situation and location. If you can sell your mineral concentrate close by, it does not need to be as concentrated compared to exporting it internationally [I1].

9.2.2 Recommendations from analysis

From evaluating the commonalities between business models as seen in figure 7.1, it is possible to identify what key traits or actions the (investigated) successful firms have in common. Then, it can be deduced that if a new firm copies their behaviour, they too may become successful, in a sort of 'monkey see, monkey do' fashion. This leads to the following recommendations.

Have a lot of partners: This is very closely linked to the recommendation of collaborating, sharing and learning, since the more partners you have, the more you can share and learn from each other and together you are stronger. These partners predominantly include the farmers themselves, research institutions, suppliers and even other (competing) installations.

Focus on product/service quality rather than price: This is again closely related to the "go for something that just works" point. Most of the interviewed successful firms opted to go for a manure processing service/system that is a higher quality and provided a better, more reliable experience rather than a lower price. As mentioned earlier in this paper, a lot of farmers want to just farm, be compliant and not be involved in the whole manure processing industry, and they appear to be willing to spend a little extra just to have it all taken care of hassle free.

Build up experience, expertise and knowledge: This is easier said than done considering a lot of this comes from learning and experience in the industry over time. However, what one can say from this is that it is very useful to do your research beforehand. Don't go with the first system you see; instead look around and get well informed on the different techniques and processes before settling on your final choice. Building up partners and sharing helps with this.

Active promotion should not be needed: Most successful firms did not need active promotion, instead relying on word of mouth and a good reputation/image for customers to approach them. As mentioned before, the industry is quite open and somehow everyone sort of knows each other, so if you build up a good firm, the customers should just come to you.

Expect to lose money on exporting the phosphate: This recommendation does not come from the commonalities figure, but it is something noteworthy across practically all relevant firms. Exporting the phosphate rich (hygienised) thick fraction costed more money to export to another country than what it sells for in that country for the participants, meaning it is likely the same for a newly starting firm. However, with the 2013 'mestverwerkingsplicht' it is not possible to decide to just not export it. Thus, participants were looking into reducing the transportation costs (e.g. further drying out the thick fraction) or extracting more value from the thick fraction. Whatever the case may be, it is good to keep in mind that the revenue of the other aspects of your firm need to be able to cover these costs and these costs can potentially increase in the future as fuel prices continue to develop.

9.3 Areas for further research

Besides of recommendations for newly starting firms in the industry, since this paper is to the author's knowledge one of the first of its kind, there are naturally also many recommendations and areas for further research.

One of the most obvious points of further research is to interview more firms. Although many firms were already contacted, the response rate was far from ideal and for this paper the focus was on interviewing successful firms to get the best insights. However, besides pushing for more interviews of successful firms, trying to include smaller and less successful firms could also be very interesting. This is because smaller firms may have different perspectives and opinions and similarly, an unsuccessful installation may know about what sort of things a firm should *not* do or what factors causes a firm to fail in the industry, both of which have not been addressed much in this paper.

Related to the previous point, having more interviews may also help in seeing if there is a relationship between firms that have multiple business aspects or business ventures. For example, a firm that produces their own installation *and* processes manure *and* in some cases also are their own transportation firm. This amount of (vertical) integration in a firm could lead to potential synergy and it could be very interesting to investigate how much of an effect or benefit this has or how much it would take to make something like that feasible.

Another important point is that currently only the Dutch market was investigated with Dutch firms and Dutch regulations. However, in reality it is more complex, since some regulations cover all of Europe, and although the Netherlands is the largest player, there are also quite a few firms in neighbouring countries such as Belgium, France and Germany. For future research a more expansive list could be made with all European firms, which will allow for a better understanding of the entire manure processing industry and perhaps potential international diffusion patterns could even be investigated. After all, currently the Netherlands is trying hard to reduce its nitrogen emissions, but as time progresses, nitrogen concerns may also arise for other countries, making manure processing an international undertaking.

Furthermore, from the limitations of this research another useful direction was identified, namely that government personnel should be investigated as well. Right now the story is generally one-sided from the agricultural perspective and there is quite a bit of pointing fingers at the government. At the start it wasn't expected that the viewpoints would be so split/conflicting. By interviewing government personnel it will be possible to see if the arguments by the agricultural industry are justified, which should help give more insights and might uncover a whole new side to the discussion.

An additional point of further research coming forth from the analysis is about biogas firms. As noted before, the contacted purely biogas producing firms generally say they do not process nor do they want to process manure. However, the interview participants that looked into it or worked with it noted it as being a potent and promising direction, especially in combination with mineral concentrates. A potential speculation of differences in profitability was given, but the real reason is still unknown. Thus, having interviews with the purely biogas producing firms will be needed to see why this discrepancy exists.

Moreover, to keep findings concise for this thesis, the focus was on just the manure processing firms that also increase or extract value from manure. However, as noted during the literature review, there are a lot of firms in the manure hygienisation and export industry. Investigating business models of those firms might also lead to more insights, or alternatively, it may be interesting to investigate what business models are useful or suited to allow those firms to reclaim more value from manure. This may be especially useful if in the future a shrinking livestock market in the Netherlands reduces the manure fee revenue, as these firms will need to transition in some way to get their revenue elsewhere or risk going out of business.

Also, this paper was relatively broad and the above points of further research are also quite broad, but it is of course also possible to go more into depth into practically any aspect of business models for the manure processing niche or even to come up with different transition strategies depending on which direction the uncertain markets goes to in the future. For example, one can set up a further investigation into the links between business models and the MLP/SNM, since only the basics have been done here due to it being a novel research topic. Within this, an example would be to find or optimize business models for certain laws or regulation changes in the manure processing industry, or investigating future empowerment paths for the industry.

Whatever the direction for further research may be, the industry holds a lot of potential and the sky is the limit, but only time will truly tell where the industry will head to in the future.

References

Alliander. (2019). *Invoeding groen gas in 2018 weer gestegen.* Retrieved from https://www.alliander.com/nl/nieuws/invoeding-groen-gas-in-2018-weer-gestegen/

Bidmon, C., & Knab, S. (2018). The three roles of business models in societal transitions: New linkages between business model and transition research. *Journal of Cleaner Production*, *178*, 903–916. Retrieved from https://doi.org/10.1016/j.jclepro.2017.12.198

Bocken, N., Rana, P., & Short, S. (2014). Value mapping for sustainable business thinking. *Journal of Industrial and Production Engineering*, *32*(1), 67–81. Retrieved from http://dx.doi.org/10.1080/21681015.2014.1000399

Boons, F., & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, *45*, 9–19. Retrieved from https://doi.org/10.1016/j.jclepro.2012.07.007

Bouraoui, F., Grizzetti, B., & Mulligan, D. (2007). An atlas of pan-european data for investigating the fate of agrochemicals in terrestrial ecosystems. *European Union*. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/2aaa8058-9d7c-4b39-8e79-aac9e1fb84dd

Catal, C., & Tekinerdogan, B. (2019). Aligning education for the life sciences domain to support digitalization and industry 4.0. *Procedia Computer Science*, *158*, 99–106. Retrieved from https://doi.org/10.1016/j.procs.2019.09.032

De Boer aan het Roer. (2022). *Webinar 14 jan 2022 alles over de subsidieregeling voor groen-economisch herstel.* Retrieved from https://www.youtube.com/watch?v=q_plQHZ9d3s

Diaz, M., Darnhofer, I., Darrot, C., & Beuret, J. (2013). Green tides in brittany: What can we learn about niche regime interactions? *Environmental Innovation and Societal Transitions*, *8*, 62–75. Retrieved from https://doi.org/10.1016/j.eist.2013.04.002

DLV Advies & Resultaat. (2021). *Mestbewerking - mestverwerking.* Retrieved from https://www.dlvadvies.nl/innovaties/mestbewerking---mestverwerking?dossier_id=27

Donner, M., Gohier, R., & H., V. (2020). A new circular business model typology for creating value from agro-waste. *Science of The Total Environment*, *716*. Retrieved from https://doi.org/10.1016/j.scitotenv.2020.137065

Dutch Emission Authority. (2019). *Wat is co2-emissiehandel?* Retrieved from https://www.emissieautoriteit.nl/onderwerpen/wat-is-emissiehandel/vraag-en-antwoord/wat-is-co2-emissiehandel

EMBER. (2021). *Daily eu ets carbon market price (euros).* Retrieved from https://ember-climate

.org/data/carbon-price-viewer/

Energy Transitions Commission. (2017). The future of fossil fuels: How to steer fossil fuel use in a transition to a low-carbon energy system. *Copenhagen Economics*. Retrieved from https://www.copenhageneconomics.com/dyn/resources/Publication/publicationPDF/6/386/1485851778/copenhagen-economics-2017-the-future-of-fossil-fuels.pdf

Environmental Protection Agency. (2019). *Agriculture sector emissions.* Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

European Union. (1992). *Richtlijn 91/676/eeg van de raad van 12 december 1991 inzake de bescherming van water tegen verontreiniging door nitraten uit agrarische bronnen.* Retrieved from https://eur-lex.europa.eu/legal-content/NL/TXT/HTML/?uri=CELEX%3A31991L0676&from=EN

Geels, F. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274. Retrieved from https://doi.org/10.1016/s0048-7333(02)00062-8

Geels, F. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy*, *33*, 897–920. Retrieved from https://doi.org/10.1016/j.respol.2004.01.015

Geels, F. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. Retrieved from https://doi.org/10.1016/j.eist.2011.02.002

Geels, F. (2012). A socio-technical analysis of low-carbon transitions: introducing the multi-level perspective into transport studies. *Journal of Transport Geography*, *24*, 471–482. Retrieved from https://doi.org/10.1016/j.jtrangeo.2012.01.021

Geels, F. (2019). Sociotechnical transitions to sustainability: A review of criticisms and elaborations of the multi-level perspective. *Current Opinion in Environmental Sustainability*, *39*, 187–201. Retrieved from https://doi.org/10.1016/j.cosust.2019.06.009

Geels, F., Kern, F., Fuchs, G., Hinderer, N., Kung, G., Mylan, J., ... Wassermannd, S. (2016). The enactment of socio-technical transition pathways: A reformulated typology and a comparative multi-level analysis of the german and uk low-carbon electricity transitions (1990–2014). *Research Policy*, *45*(4), 896–913. Retrieved from https://doi.org/10.1016/j.respol.2016.01.015

Geels, F., Sovacool, B., Schwanen, T., & Sorrell, S. (2017). Sociotechnical transitions for deep decarbonisation. *Science*, *357*, 1242–1244. Retrieved from https://doi.org/10.1126/science.aao3760

Hakim, T. (2021). Small hydro-power in indonesia: a niche development analysis. *Delft University of Technology*. Retrieved from http://resolver.tudelft.nl/uuid:a066eef1-3d67-4682

-b489-130ddf81d052

Hegger, D., van Vliet, J., & van Vliet, B. (2007). Niche management and its contribution to regime change: The case of innovation in sanitation. *Technology Analysis & Strategic Management*, *19*(6), 729–746. Retrieved from https://doi.org/10.1080/09537320701711215

Hermus, P. (2021). Halveer de autostapel en sluit schiphol. *Nieuwe Oogst*. Retrieved from https://www.nieuweoogst.nl/nieuws/2021/03/30/halveer-de-autostapel-en-sluit-schiphol

Hoogerbrugge, R., Geilenkirchen, G., den Hollander, H., van der Swaluw, E., Visser, S., de Vries, W., & Wichink Kruit, R. (2019). Grootschalige concentratie- en depositiekaarten nederland. *Rapportage 2019*, *0091*. Retrieved from https://www.clo.nl/en/indicators/en0189-nitrogen-deposition

Hoogma, R., Kemp, R., Schot, J., & Truffer, B. (2002). Experimenting for sustainable transport. the approach of strategic niche management. *Spon Press*.

Huijben, J., & Verbong, G. (2013). Breakthrough without subsidies? pv business model experiments in the netherlands. *Energy Policy*, *56*, 362–370. Retrieved from https://doi.org/10.1016/j.enpol.2012.12.073

Huygens, D., Orveillon, G., Lugato, E., Tavazzi, S., Comero, S., Jones, A., ... Saveyn, H. (2020). *Technical proposals for the safe use of processed manure above the threshold established for nitrate vulnerable zones by the nitrates directive (91/676/eec)*. Luxembourg: Publications Office of the European Union.

Kamp, L., & Vanheule, L. (2015). Introduction of small wind turbines in kenya: An analysis with strategic niche management. *Renewable and Sustainable Energy Reviews*, *49*, 470–480. Retrieved from https://doi.org/10.1016/j.rser.2015.04.082

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*, *10*(2), 175–198. Retrieved from https://doi.org/10.1080/09537329808524310

Koekkoek, E. (2021). *Stikstofuitstoot nederland: hoe zit het?* Retrieved from https://www.kvk.nl/advies-en-informatie/innovatie/duurzaam-ondernemen/stikstofuitstoot-nederland-hoe-zit-het/#beleid

Lewandowski, M. (2016). Designing the business models for circular economy-towards the conceptual framework. *Sustainability*, *8*(1), 1–28. Retrieved from http://www.mdpi.com/2071-1050/8/1/43

Lin, J., & Martin, W. (2010). The financial crisis and its impacts on global agriculture. *Policy Research Working Papers*, *9*. Retrieved from https://doi.org/10.1596/1813-9450-5431

Loorbach, D., Frantzeskaki, N., & Avelino, F. (2017). Sustainability transitions research:

Transforming science and practice for societal change. *Annual Review of Environment and Resources*, *42*, 599–626. Retrieved from https://doi.org/10.1146/annurev-environ-102014-021340

Ministry of Agriculture. (2018). *Agricultural exports worth nearly €92 billion in 2017.* Retrieved from https://www.government.nl/latest/news/2018/01/19/agricultural-exports-worth-nearly-%E2%82%AC92-billion-in-2017

Ministry of Agriculture, Nature and Food Quality. (2013). *Staatscourant van het koninkrijk der nederlanden 2013, 35686.* Rijksoverheid. Retrieved from https://zoek.officielebekendmakingen.nl/stcrt-2013-35686.html

Ministry of Agriculture, Nature and Food Quality. (2020). *Staatscourant van het koninkrijk der nederlanden 2020, 27006.* Rijksoverheid. Retrieved from https://zoek.officielebekendmakingen.nl/stcrt-2020-27006.html

Ministry of Agriculture, Nature and Food Quality. (2021). *7e nederlandse actieprogramma betreffende de nitraatrichtlijn (2022 - 2025).* Rijksoverheid. Retrieved from https://www.rijksoverheid.nl/documenten/rapporten/2021/09/06/consultatie-en-milieueffectrapportage-voor-het-7e-actieprogramma-nitraatrichtlijn

Nationaal Groenfonds. (2021). *Investeringsfonds duurzame landbouw.* Retrieved from https://www.nationaalgroenfonds.nl/fondsen/investeringsfonds-duurzame-landbouw

Nederlands Centrum Mestverwaarding. (2020). *Landelijkerapportage en inventarisatie export en verwerking dierlijke mest 2020.* Retrieved from https://www.mestverwaarding.nl/storage/article/files/2020/11/5fb7a0ddab995.pdf

Nederlands Centrum Mestverwaarding. (2021). *Analyse mestbalans 2030.* Retrieved from https://www.mestverwaarding.nl/kenniscentrum/2304/analyse-mestbalans-2030

Netherlands Food and Consumer Product Safety Authority. (2021a). *List of approved plants handling animal by-products - section vi: Biogas plants.* Retrieved from http://www3.vwa.nl/DBP_205.pdf

Netherlands Food and Consumer Product Safety Authority. (2021b). *List of approved plants handling animal by-products - section xii: Establishments or plants manufacturing organic fertilisers or soil improvers.* Retrieved from http://www3.vwa.nl/DBP_211.pdf

NOS. (2019a). *Nederlanders minder vaak dan anderen bezorgd over schade aan aarde.* Retrieved from https://nos.nl/artikel/2300184-nederlanders-minder-vaak-dan-anderen-bezorgd-over-schade-aan-aarde

NOS. (2019b). *Stikstofcrisis raakt veel meer bedrijven: "onze frustratie is enorm,".* Retrieved from https://nos.nl/collectie/13799/artikel/2306987-stikstofcrisis-raakt-veel-meer-bedrijven-onze-frustratie-is-enorm

NOS. (2021). *Greenpeace dreigt overheid met rechtsgang om stikstofbeleid.* Retrieved from https://nos.nl/artikel/2381529-greenpeace-dreigt-overheid-met-rechtsgang-om-stikstofbeleid

NUTRIMAN. (2021). *Nutrient management and nutrient recovery thematic network, farmer platform.* Retrieved from https://nutriman.net/farmer-platform

Oenema, O. (2020). Cdm-advies: 'milieueffecten bij geen derogatie van de nitraatrichtlijn'. *Wageningen University & Research.* Retrieved from https://www.eerstekamer.nl/overig/20200720/cdm_advies_milieueffecten_bij_geen/document3/f=/vlajlj9hs1po_opgemaakt.pdf

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: A handbook for visionaries, game changers, and challengers. *John Wiley & Sons*.

Osterwalder, A., Pigneur, Y., & Tucci, C. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the Association for Information Systems*, *16*(1). Retrieved from https://doi.org/10.17705/1cais.01601

Partij voor de Dieren. (2022). *Vee-industrie afschaffen.* Retrieved from https://www.partijvoordedieren.nl/standpunten/vee-industrie-afschaffen

Raad van State. (2019). *Pas mag niet als toestemmingsbasis voor activiteiten worden gebruikt.* Retrieved from https://www.raadvanstate.nl/@115651/pas-mag/

Raven, R. (2005). Strategic niche management for biomass: a comparative study on the experimental introduction of bioenergy technologies in the netherlands and denmark. *Technische Universiteit Eindhoven*. Retrieved from https://doi.org/10.6100/IR590593

Rijksdienst voor Ondernemend Nederland. (2021a). *Hoeveel stikstof landbouwgrond.* Retrieved from https://www.rvo.nl/onderwerpen/agrarisch-ondernemen/mest/gebruiken-en-uitrijden/hoeveel-stikstof-landbouwgrond

Rijksdienst voor Ondernemend Nederland. (2021b). *Overzicht deelnemers onderzoek mineralenconcentraat.* Retrieved from https://www.rvo.nl/sites/default/files/2017/02/Deelnemende-producenten-onderzoek-mineralenconcentraat.pdf

Rijksdienst voor Ondernemend Nederland. (2021c). *Regelgeving over mest.* Retrieved from https://www.nvwa.nl/onderwerpen/mest/regelgeving-over-mest

Rijksdienst voor Ondernemend Nederland. (2021d). *Subsidie voor groen-economisch herstel landbouw.* Retrieved from https://www.rvo.nl/onderwerpen/agrarisch-ondernemen/glb/plattelandsontwikkelingsprogramma-pop3-wegwijzer/subsidie-voor-groen-economisch-herstel-landbouw

Rijksdienst voor Ondernemend Nederland. (2022). *Mestverwerkingsplicht veehouder.* Retrieved from https://www.rvo.nl/onderwerpen/agrarisch-ondernemen/mest/

mestverwerkingsplicht-veehouder

Rijksoverheid RIVM. (2019). *Herkomst stikstofdepositie.* Retrieved from https://www.clo.nl/indicatoren/nl0507-herkomst-stikstofdepositie

Rijksoverheid RIVM. (2022). *Nitrogen action programme; background and current state.* Retrieved from https://www.rivm.nl/en/nitrogen

Ritchie, H., & Roser, M. (2017). *Meat and dairy production.* Retrieved from https://ourworldindata.org/meat-production

Rowley, J. (2012). Conducting research interviews. *Management Research Review*, *35*(3–4), 260–271. Retrieved from https://doi.org/10.1108/01409171211210154

Schot, J., & Geels, F. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537–554. Retrieved from https://doi.org/10.1080/09537320802292651

Smit, P. (2021). *Markt loopt warm voor koolstofboeren.* Retrieved from https://www.nieuweoogst.nl/nieuws/2021/05/14/markt-loopt-warm-voor-koolstofboeren

Smith, A., & Raven, R. (2012). What is protective space? reconsidering niches in transitions to sustainability. *Research Policy*, *41*(61), 1025–1036. Retrieved from https://doi.org/10.1016/j.respol.2011.12.012

Stuiver, M. (2006). Highlighting the retro side of innovation and its potential for regime change in agriculture. *Research in Rural Sociology and Development*, *12*, 147–173. Retrieved from https://doi.org/10.1016/S1057-1922(06)12007-7

Thelosen, J. (2021). Mineralenproducent btc de peel gaat weer gas geven. *Nieuwe Oogst*. Retrieved from https://www.nieuweoogst.nl/nieuws/2021/02/06/mineralenproducent-btc-de-peel-gaat-weer-gas-geven

TU Delft. (2021). *Msc management of technology.* Retrieved from https://www.tudelft.nl/en/education/programmes/masters/mot/mot

United Nations. (2016). *The paris agreement.* Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

United Nations. (2019). *Why nitrogen management is key for climate change mitigation.* Retrieved from https://www.unep.org/news-and-stories/story/why-nitrogen-management-key-climate-change-mitigation

van der Wal, T. (2018). *Precision farming could help reduce climate gas emissions.* Retrieved from https://www.futurefarming.com/Smart-farmers/Articles/2018/3/Precision-agriculture-helps-reduce-climate-gas-emissions-266218E/

van Dijk, W., Postma, R., Gollenbeek, L., Mostert, P., Roefs, J., & Verdoes, N. (2020). Behoefte mestbewerkingsproducten in nederland en europa: Inventarisatie perspectiefvolle product-markt-combinaties. *Stichting Wageningen Research, Wageningen Plant Research, Business unit Agrosysteemkunde*. Retrieved from https://edepot.wur.nl/528800

van Dongen, A., & Voermans, T. (2019). *Waarom liggen bouwprojecten stil? en 13 andere vragen over stikstof.* Retrieved from https://www.ad.nl/binnenland/waarom-liggen-bouwprojecten-stil-en-13-andere-vragen-over-stikstof~ad4491d5/?referrer=https%3A%2F%2Fnl.wikipedia.org%2F

Verbong, G., & Geels, F. (2007). The ongoing energy transition: Lessons from a sociotechnical, multi-level analysis of the dutch electricity system (1960–2004). *Energy Policy*, *35*(2), 1025–1037. Retrieved from https://doi.org/10.1016/j.enpol.2006.02.010

Verdoes, N., Maasdam, R., Melse, R., van Gastel, J., Gollenbeek, L., Bussmann, P., ... Roefs, J. (2021). Overzicht en beoordeling van technologie voor verwaarden van mest. *rapportage WP 2 NL Next Level Mestverwaarden*, *1290*. Retrieved from https://edepot.wur.nl/539373

Welink, M. (2020). *Vooral zorgen over geld, niet over het coronavirus.* Retrieved from https://www.boerderij.nl/vooral-zorgen-over-geld-niet-over-het-coronavirus

Winterman, P. (2019). *D66 wil veestapel halveren: drastische afname stikstofuitstoot.* Retrieved from https://www.ad.nl/politiek/d66-wil-veestapel-halveren-drastische-afname-stikstofuitstoot~a7872ea4/?referrer=https%3A%2F%2Fwww.google.com%2F

Wintermans, P. (2021). *Miljardenplan stikstofcrisis: mes gaat diep in veestapel rondom natuurgebieden.* Retrieved from https://www.ad.nl/politiek/miljardenplan-stikstofcrisis-mes-gaat-diep-in-veestapel-rondom-natuurgebieden~a0424306/

Woltjer, G., & Smits, M. (2019). De betekenis van mestverwerking in een circulaire economie. *Wageningen Economic Research nota*, *911*. Retrieved from https://edepot.wur.nl/475439

Yaskawa. (2010). *Decanter centrifuge application overview.* Retrieved from https://mobile.yaskawa.com/delegate/getAttachment?documentId=AO.AFD.65&cmd=documents&documentName=AO.AFD.65.pdf

A Appendix: Niche Actors

In this appendix the full overview is given of all 110 identified firms in the niche. These can be found on the follow pages in tables A.1 through A.5.

As mentioned during chapter 2, firms were differentiated based on how they process manure, what type/form of manure they process (the thick or thin fraction) and what (basic) type of firm they are. Namely, as mentioned in chapter 2, it was noticed that some firms offer a service to farmers of taking in manure (S), some offer the equipment or products for processing manure (P) and some firms operate for their own use only (O). This is indicated with the firm offer S/P/O column. If there were any other noteworthy points, they would be mentioned in the last column.

Please note; due to size restrictions, abbreviations are used for the table headers.

- Comp/Hyg = Compost and/or hygienisation used
- Ferm/Gas = Fermentation and/or biogas
- Comb/Char = Combustion, pyrolysis and/or biochar
- Dry/Evap = Drying and/or evaporation
- Strip/Scrub = Stripping and/or scrubbing
- Memb/RO = Membranes involved, typically via forward or reverse osmosis
- Misc. = Miscellaneous processes
- Offer P/S/O = Product, service or own usage by firm

Table A.1: Overview of manure processing firms: biochar and biogas only

Firm name:	Separation	Comp/Hyg	Ferm/gas	Comb/char	Dry/Evap	Strip/Scrub	Memb/RO	Misc	Offer P/S/O	Notes:
MAVITEC	X			X					P	Big biochar gasification and separator producer
Torrgas				X					P	Modular bio-syngas and biochar plants
Stercore				X					S	
BMC Moerdijk				X					S	
ARN		X	X	X					S	Mostly ferments, occasionally incinerates
Orgaworld Nederland	X	X	X						P/S	Creates equipment and has own plant
Bio Verwerker Anerveen	X	X	X						S	Separates and sells thin fraction
A van der Knijff	X	X	X		X				S	Thick fraction gets dried before granulating
Van Alphen Axel	X	X	X						S	
Ashorst	X?		X		X				S	Large company. Unclear if they separate/dry
Van Eijck	X?		X						S	Sells thin fraction, unclear if separates
Maatschap Aben		X	X						S	
Houbensteyn Ysselsteyn		X	X						S	
Groen Gas Goor		X	X						S	
Landgoed De Princepeel		X	X						S	Mixes food residue with own pig manure
Van der Steege/Steegro			X		X				O	Biogas generator's heat used for drying
HHV Witveld			X						O	Personal use, little info known
Groengas Kampen/ Twenterland			X						O	Uses equipment from HoSt
Wierda Co-vergisting			X						O	
Maatschap Groot-Karsten			X						O	
Melkveebedrijf de Betonpleats			X						O	

Note: only the first 4 entrants are for biochar. The rest are biogas

Table A.2: Overview of the remaining biogas-only firms

Firm name:	Separation	Comp/Hyg	Ferm/gas	Comb/char	Dry/Evap	Strip/Scrub	Memb/RO	Misc	Offer P/S/O	Notes:
De Drentse Hoeve Bioenergie			X						O	
Melkveehouderij Haarman			X						O	
Bioenergy Holwerd			X						O	
Stokman Koudum			X						O	Uses equipment from HoSt
V.O.F. Buitelaar			X						O	
Schaap Bioenergy			X		X				S	Generator's heat is used for drying
Kraanswijk Biogas			X						S	Uses own manure and of other farms
Groot Zevert Vergisting			X						S	
De Greef Agro Energy			X						S	
Biogas Marrum			X						S	95% of fermented material is manure
De Torenhoeve Biogas			X						S	
Groengas Gelderland/ Oudetonge			X						S	
Groen Has Jelsum			X						S	Half of fermented material is manure
SFP Zeeland			X						S	Half of fermented material is manure
Deeterink Bio Energie			X						S	
Agro Giethoorn			X						S	
Bio-Energie Veendam			X						S	
Biogas Heeten			X						S	
Greenlake Systems/ Varkensbedrijf Driessen			X						P/S	Makes equipment, but also ferments their own manure
HoSt Bioenergy Systems			X						P	One of the largest bio-energy systems producer in the Netherlands

Table A.3: Overview of all manure processing firms that compost or hygienise the thick fraction only

Firm name:	Separation	Comp/Hyg	Ferm/gas	Comb/char	Dry/Evap	Strip/Scrub	Memb/RO	Misc	Offer P/S/O	Notes:
HUBUN Bodemvoeding		X			X				S	Manure only accounts for a small part
TOPFertilizer		X			X				S	No seperation, just drying chicken manure
GreenDry		X			X				S	Drying and hygienising chicken manure
KOMECO		X			X				S	Uses GICOM system
GICOM		X			X				P	System used by KOMECO
Eraspo Mestverwerking		X							S	Only composting, no seperating
Ferm-O-Feed		X							S	
Legro Potgrondbedrijf		X							S	Manure only is a small part of firm
Veenbaas Potgrond		X							S	Manure part of their ground, likely compost
Primasta		X							S	
CULTERRA Holland		X							S	
Bas van Buren Substrates		X							S	Manure only accounts for a small part
Henk Meerdink & Zonen		X							O	Exports hygienised manure. No separation?
MestWater Technologie	X	X			X				P	Seperation, composting, drying equipment
Smits Agro / Wolbers Mesttechniek	X	X			X				P	Makes general and manure-specific equipment
MVB Oijen	X								S	Only mentions separation for export
Jos Mousset	X	X							S	Hygienisation and export of manure
Gebroeders van den Brand	X	X							S	
AGRO Limburg	X	X							S	Separation, hygienisation and export
Jennissen Mesthandel	X	X							S	Separation, hygienisation and export
Greenferm	X	X							S	Thin fraction dumped in sewage
Albers	X	X							S	
De Beer Leende	X	X							O	Individual farmer separating and hygienisation
DOSO	X	X							O	Personal use. Sells thick-fraction granules
Land & Pluimbedrijf Schukkert	X	X							O	Separtes and uses thin fraction as 'enrichment'

Table A.4: Overview of all manure processing firms that process the thick and thin fraction of manure

Firm name:	Separation	Comp/Hyg	Ferm/gas	Comb/char	Dry/Evap	Strip/Scrub	Memb/RO	Misc	Offer P/S/O	Notes:
Orgamex	X	X						X?	S	NL Gov. 'Mineral concentrate pilot firms'
Kumac (Kuunders)	X	X						X?	S	Also pilot firm. Process not mentioned
VEVAR	X	X						X?	O	Also pilot firm. Separates and exports
Landbouwexploitatiebedrijf Cornelissen	X	X						X?	S	Also pilot firm. Process kept secret
Heijderhoeve Agro Prod.	X	X						X?	O	Also pilot firm. Own use only
Vlako	X	X					X		S	
Mestverwerking De Kempen (Van Kuijk)	X	X					X		S	
MTOF Milieutechniek	X	X			X		X		P	
Smits Pluimvee en Eieren	X	X			X		X		O	Uses ETEKIN technology. Own usage
Taurus milieutechniek	X	X			X	X			P	
Dankers Bio Energy	X		X		X		X		S	
Agro America / BTC de Peel	X		X		X		X		S	Also on pilot list. Links with BlueSphere
Duurzaam Landleven Bernheze	X		X					X?	S	Also on pilot list. Process kept secret
Biovender Beilen/Porkwatt	X?	X	X		X			X?	S	Has 2 more locations that only do biogas
Fennenoord Gashaven	X		X		X	X			S	
Van Breda Melkvee	X		X		X	X			O	Part of 2019 mineral concetrate test
Melkveebedrijf Van Poppel	X		X		X	X			O	Part of the same test as Van Breda
Colsen	X		X		X	X	X		S	Also water treatment. AMFER tech won prize
Twence	X		X		X	X	X		S	
VP Hobe	X		X		X	X	X		P	Makes equipment for Twence and Agro America
Groene Mineralen Centrale	X		X			X	X		S	Uses technology from Nijhuis GENIAAL
Spiraloh	X		X			X	X		S	

Note: above the line is combination with compost, below the line with biogas.

Table A.5: Overview of all manure processing firms for thin fraction only and misc. firms

Firm name:	Separation	Comp/Hyg	Ferm/gas	Comb/char	Dry/Evap	Strip/Scrub	Memb/RO	Misc	Offer P/S/O	Notes:
Kamplan	X					X	X	X	S	Using bioreactor, since 1990
Merensteyn (Mestac)	X						X		S	
PromoTec / Wanner Hydra-Cell	X						X		P	Mostly makes pumps, has mebranes too
Kempfarm	X					X	X		P/S	Mineral pilot firm. Award winning
Strocon	X				X	X	X		S	
Nijhuis GENIAAL system	X					X	X		P	
Circular Values	X					X			P	
Lely (Lelysphere)	X					X			P	Cow equipment and air scrubbers. Successful
Askove					X	X			P	
MEZT							X	X	P	Award winning technology
Triqua International							X	X	S	Also for water treatment. Also has bioreactor
Aminocore								X	S	Manure microbes to make mineral concentrate
Bleekerheide en Welvard	X							X	S	Unknown process. Mineral pilot firm
Gebroeders Verkooyen	X							X	S	Unknown process. Mineral pilot firm
Geamix	X				X	X			O	Personal use likely. Still in development
AD Technologie	X								P	Manure-seperation and -belt equipment
SEPCOM / WAMH	X								P	Screw press separator equipment producer
Fabiton	X								P	Manure separators, mixers, storage and pumps
Slootsmid Manure Technology	X								P	Manure separation and general agro-equipment
Veko Ventilatie					X				P	Drying and aeration equipment for manure
DLV Advies									S	Consulting/advice for manure installations. Used by multiple firms on this list
NCM									S	Advice and general body/association

Note above the line is thin fraction only firms, below the line is miscellaneous firms.

B Appendix: Interview Content

Dutch versions of the interview content (information sheet and interview questions) were also provided to interview participants that did not speak English. For participant 8, since that participant has knowledge on the industry and players, and is a contact point, the questions were slightly altered to ask about factors he sees in the industry rather than of his own firm.

B.1 Information sheet – Dutch manure processing niche

Research Title: Business model recommendations for the Dutch manure processing niche
Researcher: Julian David Both
Affiliation: Delft University of Technology
Email: J.D.Both@student.tudelft.nl

Purpose of research:
This research has two main purposes. First, to analyse the manure processing and recycling niche in the Netherlands. This will be done by looking at actors in the niche to see what sort of networks they have, how they interact, what expectations they have and how their learning process works (to deal with factors such as regulations, new technologies and development/production). Secondly, to make business model recommendations to newly starting firms in the manure processing and recycling niche. For this, business models of different firms within the manure processing and recycling niche will be identified and the link will be made to see what works well and what does not so that recommendations can be made.

Data collection:
Data will be collected via a digital video interview. These will be recorded and used to create a transcript word for word (verbatim). The interview is expected take approximately 45-60 minutes. In case the interview participant would like to not participate in a recorded digital interview, it is also possible to answer the interview questions via email.

Data handling:
Your data will be anonymous, unless the interviewee (you, the participant) explicitly allows them or their firm to be identified in the thesis. In either case, your contact information and the digital recordings are only available to the research team for the duration of this research after which they will be destroyed/deleted. In case you would like to remain anonymous, your name and the name of your firm will also be deleted after the project and the transcripts of the interview will be anonymized, where you will be assigned a number (e.g. interviewee 6) and you will be identified as a member or employee of a firm type within manure processing and recycling. For example: "an employee of a large manure-capable biogas plant" or "an employee of a manure thin-fraction equipment producer." The data from these transcripts will be used for the researcher's thesis report and the transcript will be handed in to the researcher's graduation committee. After completion of the project, if the transcripts are kept for whatever reason, all transcripts with personal names and firm names will be anonymized.

Withdrawing:
Participation in the interview and study is completely voluntary and you have the right to withdraw and/or stop the interview at any moment. There are no consequences for withdrawing or stopping the interview and you do not need to give an explanation.

B.2 Interview questions

Opening questions:

1. Would you be ok with us using your (company) name in the thesis or would you (or your company) like to remain anonymous? (e.g. due to competition reasons or privacy)
2. Could you briefly tell a bit about your firm and what your firm does?
3. How does your firm process and work with manure?
4. Why did you or your firm decide to go into the manure processing industry?

Outside factors affecting your firm and the industry:

5. What are the main developments regarding manure processing in a broader sense (not just your firm) and/or what main factors influence the development of manure processing?
6. Were there large macroeconomic factors such as the 2008 economic crisis, covid-19 or climate change that had an effect on your firm and how?
7. Are there technical aspects outside of your firm that have a (positive or negative) effect, such as infrastructure, resource availability or even general technical developments?
8. What major rules and regulations have an effect on your firm (regarding manure processing) and how does it affect your business?

Expectations:

9. What are your expectations for manure processing technology and the industry, both now and in the future? (Expectations can be usability, performance, cost, how widely adopted it is, usefulness, etc.)
10. Has your experience or projects you have done changed/influenced your expectations?

Networks:

11. What sort of firms/organizations do you or your firm collaborate with and how (for manure processing)? E.g. part suppliers, engineers, users, researchers, governments, society, projects.
12. Are there other major/important actors (people or firms) in or around the manure processing industry that you do not collaborate with or have not mentioned yet (including main competitors)?

learning:

13. What have you learned about the manure processing industry? This can be with regard to...
    - Technological developments
    - Production development
    - Resource potential (also within manure)
    - End users (e.g. ease of use)
    - Societal/environmental impact
    - Regulations and policies
14. Has anything that you learned changed how you do business?
15. Have you or your firm encountered any problems or obstacles and how did you overcome these?

Business models:

16. Could you tell a little about how your business works for manure processing? For example, what are your main revenues and costs, what key activities do you do to generate revenue (e.g. procurement, marketing, sales) and how do you acquire and retain new customers?
17. What advantages does your firm and/or manure processing system have compared to other competing manure processing-related firms?
18. What do you think is preventing/constraining you from growing and becoming more successful? Or what do you think you could do better or should improve on?

Final Questions:

19. What do you think needs to be changed or what actions should be taken in the (overall) manure processing industry to improve the adoption of sustainable manure processing technologies?
20. If you could give any recommendations to new firms starting in the manure-processing industry, what would it be?
21. Do you have any other interesting or useful points you would like to share regarding the manure-processing niche/industry?