Exploring fertilization innovations on their potential impact on dairy- and fertilization companies

The case of the spoked-wheel fertilizer and the disc-injection fertilizer

MSc Thesis

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- MSc Thesis Management Studies -

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Management Summary

Introduction and theoretical framework

Currently the Dutch dairy sector is developing towards a sector with large interest to improve the sustainability. Besides this, the Dutch dairy sector has to deal with several challenges that have emerged the past years. The quota free era was entered on the 1st of April this year, however, from 2016 Dutch dairy farms receive a maximum-limit of phosphate they are allowed to produce. Another restriction for the growth of dairy farms is land-based growth of dairy farms, this restriction will also be introduced January 2016 and aims to prevent too much intensifying of the dairy sector.

In order to make the Dutch dairy chain more sustainable the initiative of the 'Sustainable Dairy Chain' has formulated 4 general goals for 2020 (Duurzame Zuivelketen, 2015):

- Development towards climate neutrality
- Continuous improvements in livestock health and welfare
- Preservation of grazing
- Protecting biodiversity and the environment

These goals are themes that are crucial for the license-to-produce of the Dutch dairy sector. In addition to these 4 themes dealing with the manure surplus of the Dutch dairy sector is also important for developing the Dutch dairy sector sustainably. The Dutch government attempts to reduce the manure (and phosphate-) surplus with laws: manure-processing obligation, land-based growth of dairy farms, phosphate rights, and derogation. Solutions to deal with the manure surplus, but also with the greenhouse gas emissions and the restrictions for the dairy farms, are manure processing into liquid fertilizer, acidification of manure and smart fertilization.

Smart fertilization is a trend in which sustainability and profitability are combined, therefore, this trend is further scrutinized since it might help Dutch dairy farmers to deal with the challenges and restrictions they face. Currently there are two types of 'smart fertilizers' that are used in the Netherlands on grassland, because grassland is the major source of forage in the Dutch dairy sector, these innovations are the subject of this research. The innovations are two liquid fertilizer injectors; the recently developed disc-injection fertilizer and the more common spoked-wheel fertilizer. The disc-injection fertilizer was developed by a contractor and injects liquid fertilizer in incisions in the soil. The spoked-wheel fertilizer is produced by two manufacturers and injects the liquid fertilizer in the soil through its spokes.

The objective of this research is to gain insight on the impact of the challenges and potential solutions for these challenges faced by the Dutch dairy sector, with a special focus on two emerging innovations, the spoked-wheel fertilizer and the disc-injection fertilizer, on the dairy farms, the fertilizer industry, and the fertilization industry operating in the Netherlands.

The central research question for this research is: **What might be the impact of the spoked-wheel fertilizer and the disc-injection fertilizer the dairy farms, the fertilizer industry, and the fertilization industry operating in the Netherlands?** In order to answer this research question, the following specific research questions have to be answered:

SRQ 1: Which of the two innovations could become successful in the Dutch dairy chain and thereby help this chain become more sustainable?

SRQ 2: What might be the impact of the spoked-wheel fertilizer and/or the disc-injection fertilizer on Dutch dairy farms and the fertilizer industry and the fertilization industry operating in the Netherlands?

SRQ 3: What is the effect of the innovations on the capability of Dutch dairy farmers to deal with the challenges and regulations they face?

Methodology

The data-collection was done by means of a Delphi-study. 32 respondents have been interviewed during the two rounds of the Delphi-study. The background of the respondents can be divided as follows: 10 respondents with expertise on smart fertilization, 5 dairy farmers, 5 contractors, 10 respondents with expertise on the Dutch dairy chain in general, and two experts on specific subjects (high-pressure injection and alternative medicines). In the first round the respondents were interviewed face-to-face in order to list as much relevant aspects as possible. The interviews of the first round were held according to the interview-cycle. During the second round the respondents reacted and shared their vision on the regulations, challenges and potential solutions that were given by respondents during the first round. The second round was conducted by telephone.

The business model of the spoked-wheel fertilizer and the disc-injection fertilizer has been analysed by means of the Business Model Canvas. In addition to that, the potential impact on the Dutch dairy farms and the companies in the fertilizer industry and fertilization industry was analysed. The industry to which the spoked-wheel fertilizer and the disc-injection fertilizer belong is analysed by means of Porter's five competitive forces model, with the practical application of Grundy's vector format in order to place the forces in perspective. The challenges, regulations and potential solutions that are subject of this research each have been addressed by 1 to 8 respondents. The number of respondents per subject depended on the amount of times the subject was mentioned in the first round, the relevance of the subject for achieving the goal of this study and the number of respondents that actually appeared to have expertise on the subject. Strengths, Weaknesses, Opportunities and Threats-analysis (SWOT-analysis) is used to assess the potential for success of the innovations that are subject of this research. The strengths, weaknesses, opportunities and threats are listed and prioritized based on the input of the respondents and the literature. After this, a Threats, Opportunities, Weaknesses and Strengths-matrix (TOWS-matrix) was executed with the SWOT results as input in order to see how the internal factors react with the external factors.

Results

The Dutch dairy chain is a significant chain in the Dutch economy. An overview of the size of this whole chain is formulated to provide insight on the scope of this chain. The value added by the Dutch dairy is good for 6.3 billion Euro which equals 1.2 percent of the Grand Domestic Product (GDP) of the Netherlands. There are 17.800 dairy farms with 1.55 million dairy cows which produce 12.4 billion kilograms of milk. There are 60.000 people working in the production, processing and retail of dairy products. The Dutch dairy chain is part of the agri-food sector, in total this sector accounts for 9 percent of the Dutch GDP (ZuivelNL, 2013). The fertilizer industry exists out of the suppliers and producers of fertilizer. Fertilizer is often delivered by the feed mill but there are also companies that are specialized in fertilizer (Triferto, 2015). The process is as follows: raw materials are bought by the fertilizer producer and are then processed into the ready-to-use form. Then the fertilizer is sold to feed mills or directly to the dairy farms. The fertilization industry is the industry with the producers of fertilizer equipment (Tier 2 and 3), the dealers in fertilizer equipment (Tier 1 and 2), and the contractors who apply the fertilizer on the land of dairy farms (Tier 1).

The industry analysis of the fertilization industry was done by Porters five competitive forces and is displayed in Grundy's vector format below. All the vectors larger than 0 represent a positive effect for the liquid fertilizer injectors at issue. The negative vectors have a negative effect,

meaning they form a threat to the liquid fertilizer machinery producers in the fertilization industry.

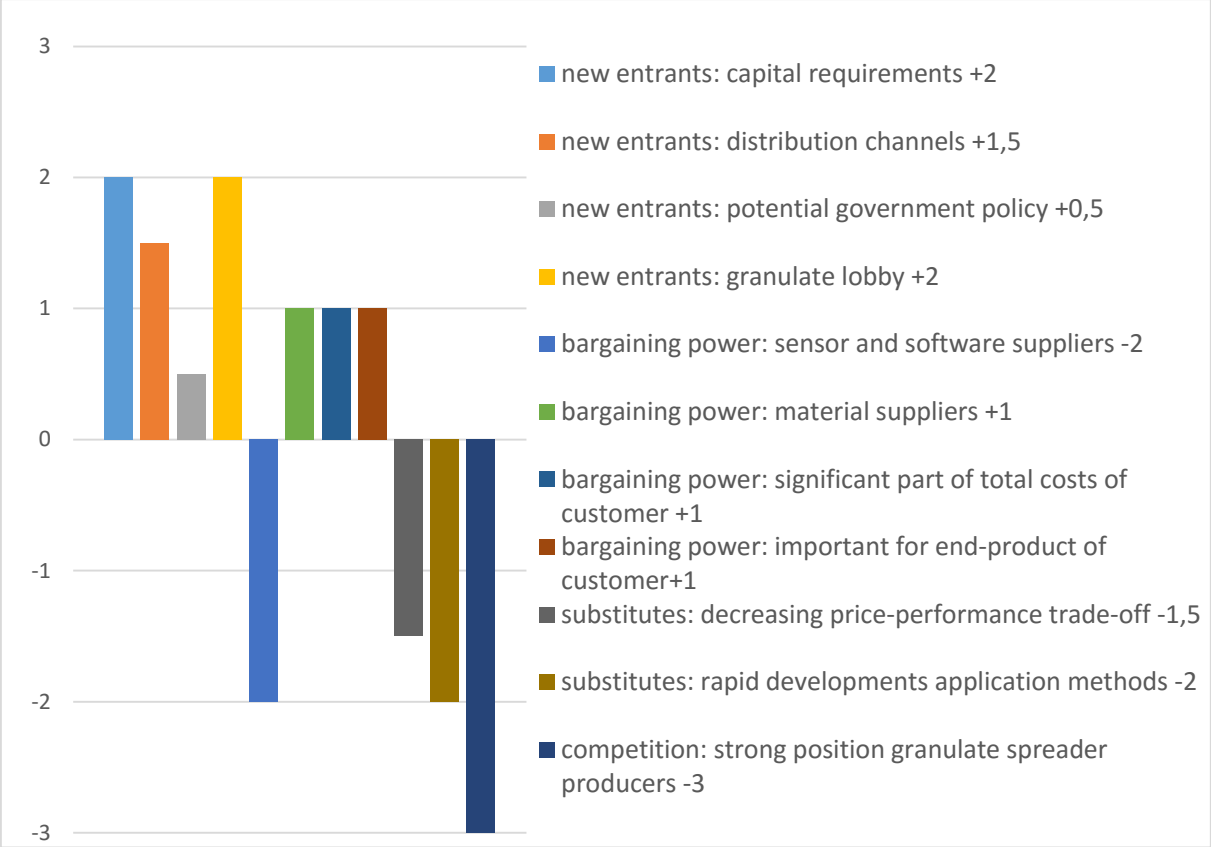

Figure 1: Vector format from the perspective of liquid fertilizer injector producer

The liquid fertilizer injectors at issue are already developed and therefore the high capital requirements for new entrants are favourable, since they already have fulfilled these requirements. The rapid developments of substitutes form large threat for the liquid fertilizer producers since the substitutes will most likely outperform them, resulting in a better price-performance trade-off for the substitutes in comparison with the spoked-wheel fertilizer and the disc-injection fertilizer. The strong position of the granulate spreader producers is the largest threat for the spoked-wheel fertilizer and disc-injection fertilizer because the granulate spreader producers are backed by the strong granulate lobby.

The challenges, regulations and potential solutions that have been analysed in this research are split up in two types of subjects; the causes that challenge the Dutch dairy farmers to be more sustainable and the potential solutions that deal with these challenges by enabling them to increase the sustainability of their enterprise.

The challenges for the Dutch dairy sector

Phosphate rights will be introduced the 1st of January 2016. The advantages of phosphate rights is that dairy farmers are now strongly stimulated to be as efficient as possible with phosphate, this will result in all-round increase in mineral efficiency which is beneficial for the environment as well as for the dairy farmers because then they can keep more cows with the same phosphate rights. Respondent 4J states some methods for steering the phosphate efficiency on the dairy farms:

4J:"Dairy farmers can steer to stay under the phosphate-ceiling by for example; reduce the amount of young stock they keep, and feed less phosphorus, so less phosphate is produced on the farm."

The largest disadvantage is that the market is (again) restrained and growth is limited. Dairy farmers have to do a larger investment in case they want to expand. The cycle indicator will be an increasingly important tool for dairy farmers and their consultants to make the cycle as efficient as possible. More dairy farmers without a successor will quit while the phosphate rights can form an extra source of money for retirement. Prices for land will stabilise instead of rising further because of the decrease in growth of dairy farms the phosphate rights will cause. A new trade flow will emerge for the phosphate rights. The effect of the introduction of phosphate rights on grazing is something the respondents could not agree on; two of the five respondents think less cows will be grazing because of the negative effect on the mineral-cycle, two other respondents oppose this because the grazing of cows is an image matter and any decrease will be prevented.

Manure legislation might be changed into farm-specific use limits based on mineral efficiency. Whether the use limits for nitrogen and phosphate will be sharpened depends on nitrates directives being met or not. Respondent 1A expects that these directives will not be met and therefore the use limits will be sharpened. 1G opposes this because the directives are almost met. Two other respondents, 1I and 3C, expect the use limits will not be sharpened because the phosphate rights will control the use of minerals enough. If manure legislation is sharpened or changed it is expected to happen in 2020 with the start of the reformed Common Agricultural Policy (CAP) by 1G, 2B, 1I, 1A, and 3C. 4E however states that the next nitrate action program already activates in 2018, and that changes will be introduced in this action program.

1A and 4E expect the legislation to become more company-specific. Where 1A expects that the use limits will vary based on soil-type, 4E expects use limits based on the performance on mineral efficiency of each dairy farm:

4E: "There will be more differentiation between dairy farms, those who perform well with regards to mineral efficiency will be allowed to use more manure and fertilizer, and the underperformers will have to deal with sharper use limits."

The vision of 4E thereby also accounts for soil-type, as the dairy farmers are rewarded or restricted based on how well they cope with the soil-type on their farm.

In the future a low CO2 (-equivalent) footprint per kilogram milk will be rewarded, and/or reduction of greenhouse gas emissions becomes compulsory. 4G, 4J, and 4I expect the dairy processors to reward dairy farmers who realize a low footprint of CO_2 per kilogram milk. However, 4G states that if this reward does not stimulate CO_2 reduction enough, the government will intervene with restrictions. 1G and 1C expect that the government will not wait for this and will set restrictions much sooner. 1G expects a CO_2 tax where dairy farmers pay a tax for the level of CO_2 they produce on their farm. 1C is not certain whether the government will reward low or punish high CO_2 production, but thinks a CO_2 –ceiling will be set by the government. Respondents 4J, 1D, 4I, 1C, and 3A all expect restrictions on the amount of greenhouse gasses that are produced by a dairy farm.

It remains quite uncertain how grazing will develop. Respondents 3B, 1J, 4F, 4I, and 4E answered questions on how this will develop. The respondents did not agree at all on how the percentage of cows grazing will develop in the Dutch dairy sector. 3B expects it to remain at the current level of approximately 70 percent, whereas 4I thinks the cows will determine how much is ideal for them. 1J expects the percentage of cows grazing to increase to 80 percent because that is the goal the sector has set for itself. When the 80 percent is not reached by the sector itself, 1J

expects the government to intervene. 4F thinks along the same line, but is convinced all the cows will graze in The Netherlands:

4F: "Over 10 years the grazing percentage is 100 percent because grazing will become obligatory if the dairy processors cannot get this percentage high enough by rewarding for grazing!"

4E opposes to the intervening of the government regarding grazing, expecting the sector to take care of it. All respondents agree that in the dairy processors will influence the percentage by paying a premium per kilogram milk, as they currently are doing already. 3B expects an additional premium per kilogram milk from the government. 4I states that the study evenings of young farmers also positively influence the grazing percentage. The disadvantages of grazing are a reduction of grass yield, a limitation for expansion, it is less labour efficient because the grassland management is rather complicated. The effects on emission are diverse; the mineral efficiency is lower because the manure and urine are not efficiently placed, but the ammonia emission is lower due to the fact manure and urine do not come into contact with each other. 4E expects that the end-balance of emissions by grazing will be the same as for housing the cows throughout the year

The potential solutions for the Dutch dairy farmers

Liquid fertilizer injection will be used increasingly in the dairy sector the coming decade. Respondents 1C, 1F, 3A, 1E, 1D and 1A answered questions on this potential solution. 1D and 1F did not agree with the statement that liquid fertilizer injection would be used by more than 40% of the dairy farmers in 2025, the other respondents did. All these respondents did agree that the use of liquid fertilizer injection would increase amongst dairy farmers. The main motives for this growth in usage are the demand for increasing mineral efficiency, cutting costs, and in the future expected environmental restrictions and/or rewards.

Site-specific fertilization will emerge in the coming decade. Respondents 1C, 2B, 2E, 2C, 1E, and 4F answered questions on this development. The respondents all agreed on the main advantage of site-specific fertilization; as much utilization of fertilizer as possible. 1E explained it as follows:

1E: "By providing in site-specific demand, the yield will increase as will the mineral efficiency. This will lead to less fertilizer per hectare."

Thinking further along this line, 1C stated that the mineral efficiency is also rewarded by the cycle indicator and the phosphate rights. The largest step that has to be taken before site-specific fertilization can come to practice is the development of the sensors that can determine the site-specific demand of plant and soil.

The usage and valorisation of waste-streams will increase. Respondents 1G, 3B, 1C, 1I, 2E, 2C, 1J, and 4F answered questions on this potential solution. All these respondents agreed with the prediction use and valorisation of waste-streams would increase in the future.

The major advantage of the use of waste-streams is that it saves produced fertilizer and thereby pollution is decreased since less production and transport is required. In general the waste-streams are also cheaper compared to produced fertilizer. Another advantage was recognized in a better cycle of streams, since waste-streams do not have to be produced and they exist anyway, no energy is lost in de production process.

Refining manure so that it can be used as fertilizer will become possible. Respondents 1G, 1C, 1I and 4E answered questions on this potential solution. All respondents expected manure refinery into fertilizer will be done in the future.

When manure refinery is developed to the level where it can process manure into fertilizer and is allowed to be used as fertilizer, there are several advantages to it: Less fertilizer is needed because

more manure is used instead, therefore the manure-surplus will decrease. The manure is more efficient, this has a positive influence on the cycle indicator which means more cows are allowed with the same phosphate-rights. When farms still have to cope with a surplus, there will be a lot more of companies demanding refined manure and the refined manure can also be further transported.

Smart fertilization increases protein yield per hectare grassland. 4E and 1A agreed to this statement with the current methods, however, the effect of the current smart fertilization is for the 3 other respondents (4F, 4G, and 1D) too little to agree with this statement. When site-specific fertilization is in practice the same 3 respondents also agree with the statement. 1A however claims that increase of the protein content is already possible by applying the right form of nitrogen; ammonium nitrogen and amide nitrogen. In addition to that the precise placement and full coverage of the field should result in an overall increase in grass yield and thereby also protein yield. 1D expects that through a better timing of fertilization the overall grass yield can also increase. The advantages of an increase in total grass yield and protein yield per hectare grassland (with the same amount of fertilizer) are the following: The environment and the mineral cycle are benefitted because less minerals are lost via emissions, the dairy farmers are allowed to have more cows because of a better mineral cycle. Another beneficial effect for the environment and the dairy farmer is that less protein-rich fodder has to be bought by the dairy farmers, causing less CO2 emission by production and transport of this fodder and cost savings for the dairy farmer. Thereby, the dependency on international feed sources will decrease, and dairy farmers will be more self-sufficient.

Robot fertilization will emerge on the long term in the Dutch dairy sector. Respondents 1B, 2D, 2E, and 1A answered questions on this potential solution. Robot-fertilization saves labour, causes less rutting because of the lighter machines, increases mineral efficiency because it can apply the fertilizer multiple times, and is more accurate. The downsides to this form of fertilization are the high price and maintenance cost, and it will be sensitive for malfunction. Fully automatic fertilization robots will take time to develop, for its development the automotive sector will be a leading example according to respondent 1A.

1A: "The developers of robot fertilizers will follow the developments of the automotive industry on robot-cars closely, since the resources of this industry enable much more progress."

The respondents did not agree on when the fully automatic fertilization robots will be in practice in the dairy sector. 1B stated that robots with the currently existing fertilization methods will be in practice within the coming ten years, and that site-specific fertilization robots will be in practice after those ten years. 1A expects fully automatic robots within fifteen years from now and 2E expects it to be over fifteen years. 2D expects that robot-fertilizers will not come to practice at all, because they will be too expensive.

SWOT- and TOWS-analysis

In the matrices below the Threats, Opportunities, Weaknesses, and Strengths-matrices (TOWS) of the innovations are displayed. The input of these matrices comes forth out of the Strengths, Weaknesses, Opportunities, and Threats-analysis (SWOT), in which the internal and external aspects that are relevant for the innovations have been analysed and given a weight for their relevance.

TOWS Matrix Spoked-Wheel Fertilizer			Strengths					Weaknesses					
			precision	little emission	processing of liquids	injected in rootzone	proven technique	expensive	not site-specific	weight	capacity	has to be done by contractor	space between placement
			5	4	3	3	2	5	4	3	3	2	1
Opportunities	resource efficiency	5	+++	+++	++	+	+	--	---	-	-	-	-
	attention for the environment	5	+++	+++	+	++	0	0	---	-	--	-	-
	more outsourcing and specialization	2	++	0	+	+	0	-	--	+	-	++	0
Threats	granulate fertilizer lobby	5	++	+++	-	+	++	---	0	---	---	--	-
	competition	4	++	+++	+	+	++	---	-	--	--	--	-
	mentality	3	+	+	+	0	++	---	0	-	-	--	0
	liquid fertilizers	3	+	0	0	0	0	-	--	0	0	-	-
	governments	1	++	+++	++	++	+	0	--	0	0	0	-

Figure 2: TOWS Matrix Spoked-Wheel Fertilizer

TOWS Matrix Disc-Injection Fertilizer			Strengths							Weaknesses								
			precision	value for money	robust	processing of liquids	combinable with manure spreading	little emission	injected in rootzone	cuts through the soil	capacity	not site-specific	not proven itself	high emissions	expensive	has to be done by contractor	weight	space between placement
			5	4	3	3	2	2	1	5	4	4	4	4	3	2	2	1
Opportunities	resource efficiency	5	+++	+	+	++	++	++	+	--	-	---	--	---	--	-	-	-
	attention for the environment	5	+++	0	+	+	++	++	+	--	---	---	-	---	0	-	-	-
	more outsourcing and specialization	2	+	0	+	+	++	0	+	-	-	--	--	--	-	++	+	0
Threats	granulate fertilizer lobby	5	++	++	++	-	++	++	+	---	---	0	---	-	--	--	--	-
	competition	4	++	+++	++	+	++	++	+	---	---	-	---	--	--	--	--	-
	mentality	3	+	++	+	+	+	+	0	---	-	0	--	--	--	--	-	0
	liquid fertilizers	3	+	0	0	0	0	0	0	0	0	--	-	--	-	-	0	-
	governments	1	++	0	0	++	+	++	+	--	0	--	--	---	0	0	0	-

Figure 3: TOWS Matrix Disc-Injection Fertilizer

The strengths of the disc-injection fertilizer of precision and processing of liquids have the same interactions since the weights are the same as for the spoked-wheel fertilizer. The disc-injectors' strength of little emission and injected in rootzone however have less weight compared to the spoked-wheel fertilizer, therefore their interactions are also less positive. The strengths of the disc-injection fertilizer that were not recognized for the spoked-wheel fertilizer give the disc-injection fertilizer some competitive advantage: The value for money strength has a strong positive interaction with the threat of competition. The fact that this method can be combined with manure spreading has positive interactions with all external factors except for the threat of the liquid fertilizers.

The weaknesses has to be done by a contractor, not site-specific, and space between placement have the same weight assigned for both fertilizer injectors. Because the disc-injection fertilizer is less expensive the interactions are also less negative, the same effect is applicable for weight. But the lower weight is at the expense of the capacity of the machine, therefore the interactions

between capacity and the external factors are also more negative. The weaknesses of the disc-injection fertilizer that do not apply for the spoked-wheel fertilizer, not proven itself, relatively high emissions, and cutting through the soil, have a very high weight and show strong negative interactions with all external factors. These last mentioned weaknesses give the machine a severe disadvantage when the comparison is made against the spoked-wheel fertilizer.

Conclusions

This research has shown that the spoked-wheel fertilizer has the best credentials for becoming successful in the Dutch dairy sector, because, on the short term the spoked-wheel fertilizer is the most precise and efficient compared to all other fertilization methods, and on the (medium-) long term the spoked-wheel fertilizer only needs to be developed so that it can apply fertilizer site-specific. The disc-injection fertilizer on the other hand has too many and too weak characteristics according to the TOWS analysis in this study, that it is not expected that this fertilization method will be a widely used method in the Dutch dairy sector.

When one or both of the innovations become successful in the Dutch dairy chain, based on this study probably the spoked wheel fertilizer, the business models of (artificial-) fertilizer-suppliers and contractors will change radically since the supply and application of liquid fertilizer are expected to become one of the Key Activities of these enterprises. Besides that, liquid fertilizer suppliers, liquid fertilizer producers, manure processors, and waste-stream valorisation companies are expected to benefit from an increased demand for their products and services whereas feed suppliers, granulate fertilizer suppliers, granulate fertilizer producers, granulate spreader producers, and competitors of the innovations are expected to see a decrease in the demand for their products and services.

All results considered the major challenge for the Dutch dairy sector is **resource efficiency**; efficiently handling the available minerals, land, crops, animals, medicines, labour and capital. The suppliers of Dutch dairy farmers have to increase their own resource efficiency and have to enable the Dutch dairy farmers to increase their resource efficiency as well. The challenge for resource efficiency comes from two sides; the environment and the profitability. For the environment an increase of the resource efficiency is essential, when the resources are utilized as efficient as possible, as little as possible spillage which pollute the environment remains. For the profitability of dairy farms the resource efficiency is equally important, since it is a direct indication of the profitability of the enterprise. After all, an improved production with less resources means a higher turnover with less costs. All the challenges and potential solutions that were analysed during this research bring the Dutch dairy sector, the fertilizer-industry and the fertilization-industry towards a more sustainable and efficient chain. Not only these industries benefit from these developments, also the dairy processors, retailers, consumers and the environment.

Recommendations

- The fertilizer-producers are advised to diversify their product-range
- The fertilizer-suppliers should also widen their product-range to respond to the growth in the usage of liquid fertilizer.
- For the producers of the fertilization machines the recommendation is to invest in the development of a machine which is able to apply the fertilizer site-specific.
- The dealers and traders active in the agricultural machinery (the fertilization suppliers) are advised to add the spoked-wheel fertilizer to their product-range despite the extra costs for training of employees (if not already added)
- The contractors are advised to invest in liquid fertilizer injection with special attention for the ability of (conversion to) site-specific application.

- The most important recommendation for Dutch dairy farmers that can be provided based on this research is (in general): Invest in resource efficiency. The resource efficiency can be improved on several aspects within the Dutch dairy sector:
    - Firstly, the mineral management is of vital importance given the challenges for the Dutch dairy sector described by this research. In order to perform the mineral management as efficient as possible several measures are currently applicable:
        - Liquid fertilizer injection
        - Timing of fertilization
        - Timing of harvesting
        - Fertilizing according to demand instead of usage,
        - Manure processing to enlarge the efficiency
    - Besides these measures the future is expected to bring more possible methods to increase the mineral efficiency:
        - Site-specific demand-analysis and fertilization,
        - Manure processing into fertilizer
        - Robot fertilization
    - In addition to increasing mineral efficiency there are other aspects on which the resource efficiency can be increased in the Dutch dairy sector. According to the results of the Delphi-study and literature study in this research it is advisable for dairy farmers to;
        - Increase the average lifetime of their cows (less breeding costs per lactation)
        - Construct their stables according to do the 'Maatlat Duurzame Veehouderij' (Yardstick Sustainable Livestock)
        - Monitor the health of their cows more individually and intensely
        - Increase the labour-efficiency by for instance automating the 'simple' tasks such as feed pushing or by outsourcing the machinery-labour to a contractor.

When the dairy farmer increases the resource efficiency, the profitability of his or her farm will increase as well.

Limitations

- The conclusions that are drawn in this research are based on a few experts and in some cases merely on individuals.
- 2 of the respondents were not interviewed face-to-face
- The investment aspects could not be analysed because of the great variation and uncertainty amongst the respondents regarding this aspect
- The interviewing method of the second round changed after the first round was completed, because the original setup would not generate in-depth insights
- Only two rounds were held. The respondents that were interviewed at the beginning of the second round have had no chance to react on the responses of the interviewees that were interviewed after them.
- 5 of the 30 original respondents did not participate during the second round, of which 4 were from the Dutch dairy chain panel
- During this research significant developments occurred in the Dutch dairy sector of which the announcement of phosphate rights is the most important one. This restriction changed the outlook for the sector and thereby the impact of other restrictions and challenges.

Table of Contents

1. Introduction

This chapter contains the introduction on the context of this research and the conceptual research design where the research objective, research framework, research questions and the definitions of concepts and operationalization will be addressed. The conceptual research design aims to clarify and set the limits for the regarding research. It answers the questions what, why and how much will be studied (Verschuren & Doorewaard, 2010).

1.1. Introduction

The Dutch dairy sector is a very dynamic one, considering the innovations and trends that emerge in rapid fashion. A current trend in the Dutch agri-food sector is an increasing importance of production with an eye for sustainability, the environment, animal -, and human welfare (Mulders, 2013). The Dutch dairy chain is no exception regarding these trends in production methods. In addition to these trends there are several other developments the Dutch dairy chain has to deal with. Last April the Dutch dairy chain entered the 'quota-free era', the Dutch dairy farmers have been preparing their enterprises for the quota-free era for the past years. New dairy housing is being build and more cows are held. However, this era of unrestricted production will not last long. On July the second of this year a new restriction was announced for dairy farms; phosphate rights. This new restriction was announced because the Dutch dairy farmers could not stay under the phosphate-ceiling that was set at 84.9 million kilograms, in 2014 (even before the abolishment of the milk-quota) this ceiling was already exceeded with a total production of 86.1 million kilograms, after the abolishment the growth in numbers of dairy cattle was so large, the Dutch government saw themselves forced to interfere (Rijksoverheid, 2015). Per January 2016 dairy farms will receive a maximum-limit of phosphate they are allowed to produce based on the amount of dairy cattle that was present before the announcement of the phosphate rights. In order to get the dairy sector below the phosphate-ceiling that was set, the rights might be reduced with, for instance, a factor 0.985 (Van Den Pol, 2015). Despite the lack of clarity on the exact implementation of phosphate rights, it is clear that the Dutch dairy chain once more will be restricted in growth and production (MKB-adviseurs, 2015). Another restriction that is announced for January 2016 is the land-based growth of dairy farms, which also restricts growth of dairy farms based on phosphate production. When dairy farms want to grow and they have a phosphate surplus of less than 20 kilograms per hectare the farmers are allowed to choose whether they process the surplus or if they buy extra land and thereby more room for phosphate. In case of a phosphate-surplus of 20-50 kilograms per hectare, a quarter of their growth in phosphate production have to be applied on their own land, so when they want to grow the dairy farmers have to invest in land as well. When the phosphate surplus is over 50 kilograms per hectare, half of the extra phosphate has to be applied on extra land. This measure is set so that the Dutch dairy chain remains and strengthens their land-based character. In addition to that it helps

Box 1: The Dutch dairy chain

The research will be carried out in the first part of the Dutch dairy chain, therefore, a short overview of the size of this whole chain is formulated to provide insight of the scope of this chain. The value added by the Dutch dairy is good for 6.3 billion Euro which equals 1.2 percent of the Grand Domestic Product (GDP) of the Netherlands. There are 17.800 dairy farms with 1.55 million dairy cows which produce 12.4 billion kilograms of milk. There are 60.000 people working in the production, processing and retail of dairy products. The Dutch dairy chain is part of the agri-food sector, in total this sector accounts for 9 percent of the Dutch GDP (ZuivelNL, 2013).

to improve the percentage of cows grazing in the Netherlands (Rijksoverheid, 2015). These restrictions and the increasing attention for sustainability, environment, animal -, and human welfare are all increasing the cost-price of a kilogram of milk (Genootschap Melkkunde, 2009), (Van Den Pol, 2015). Therefore, a demand for innovations that improve the profitability but also improve the sustainability of the Dutch dairy farms are necessary in order to maintain the possibility and the license to produce.

The fact that potential customers, governments, animal welfare-activists, retailers and even actors in the supply chain value (and demand) the aspects of sustainability and welfare more and more leads towards an incredible range of innovations in the agri-food sector. These innovations occur in all chains in the agri-food sector and the Dutch dairy chain is no exception. Where innovations originally were focussed on production increase and automation, a shift has been made towards the more sustainable innovations (Hassink, et al., 2014). The Dutch dairy chain is currently undergoing rapid (sustainable) changes on several different facets in the chain. For example, the use of antibiotics is reducing quickly due to regulations from the government, the corporate social responsibility of the businesses in the dairy chain and pressure from society. This leads to new innovative methods to treat and prevent udder-infections such as mastitis. An example of such an innovative method is the use of garlic-extract, which holds the enzyme alliinase that possesses anti-bacterial properties against mastitis-causing bacteria like Staphylococcus aureus, Streptococci spp., Escherichia coli and Klebsiella spp. (Vingerhoets, 2014). A development regarding welfare and health of the dairy cows is the increasing demand for outdoor grazing. It has been proven that grazing of the dairy cows improves the health and provides better animal welfare in comparison to dairy cows in confinement systems (Washburn, et al., 2002). However, grazing is also considered to be cultural heritage in the Netherlands and therefore it is demanded and stimulated increasingly (Rijksoverheid, 2015), (Hogenkamp, 2014). In the Dutch agriculture sector a certificate for sustainable housing was founded: 'Maatlat Duurzame Veehouderij (MDV)' which literally means 'Yardstick Sustainable Livestock'. It certifies on ammonium-emission, animal health, animal welfare, energy usage, fire safety and particulates. The Dutch government grants tax-advantages to motivate dairy farmers to apply for this certificate (SMK, 2015). This MDV initiated several innovations. One of them is the 'De Groene Vlag Plus' a slatted concrete floor with a convex thermoplastic rubber top-layer, with rubber flaps that seal the underlying manure-storage pit. This type of flooring results in an ammonia-emission of 4,1 kg NH3, which is remarkably low compared to the 9,5 kg NH3 that is currently allowed per cow-place per year. The company that developed this innovative floor even claims that it is on top of the RAV-list, the list where the ammonium-emission is listed (Den Boer Beton, 2015). Figure 4 is a schematic display of the rubber flaps between the concrete slatted floor.

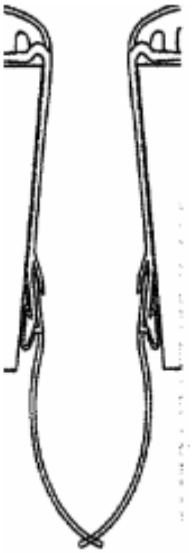

Figure 4: Schematic overview 'De Groene Vlag Plus'

These examples are merely a glimpse of what innovations are out there or being developed at the moment in order to improve the sustainability of the Dutch dairy farms. It is unknown what the type, impact and potential will be of the currently developing innovations. Therefore, this study aims at exploring two of these emerging innovations in the Dutch dairy chain to develop insight on the type of innovation and on the potential impact they might have on this chain. Both innovations are liquid fertilizer injectors following the trend of 'smart fertilization'. Currently there are two types of 'smart fertilizers' that are used in the Netherlands on grassland, because grassland is the major source of forage in the Dutch dairy sector, these innovations are the subject of this research. The main goal of smart fertilization is to increase the mineral efficiency in order

to gain maximal yield and minimal pollution, in other words; **improve the profitability but also improve the sustainability of the Dutch dairy farms.** Besides the research after these specific innovations, impactful challenges and potential solutions for these challenges and their implications for the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands will be brought to light. The relevance of this research comes forth out of the lacking of an independent vision on these potential solutions and the impact of these two innovations. By forming a future vision based on specialists with many different relevant perspectives and interests this research will provide a handle for companies and entrepreneurs who are looking how and where to invest. Currently consultancy to dairy farmers is often provided from a specific perspective by a person or company with interests in a certain direction of development of the farm at issue (Van Ginneken, 2013). A vision on this chain which is developed with complete independence and objectivity is what makes this research worth the execution. Another aspect that makes this research relevant is the disagreement in visions within the dairy sector. In this sector completely opposing visions and research results can be found. By confronting experts with each other's vision this research aims at providing a nuanced vision on the major restrictions, challenges and potential solutions which await the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands.

1.2. Conceptual Research Design

1.2.1. Research objective

As described at the introduction, this research will scrutinize the challenges, potential solutions and two particular innovations that might change practice for the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands. The innovations will be assessed on several aspects in order to conclude whether or not they are expected to be successful and will improve the way dairy farms conduct their business in the Netherlands. **The objective of this research is to gain insight on the impact of the challenges and potential solutions for these challenges faced by the Dutch dairy sector, with a special focus on two emerging innovations, the spoked-wheel fertilizer and the disc-injection fertilizer, on the dairy farms, the fertilizer industry, and the fertilization industry operating in the Netherlands.** The aspects that will be examined in this research in order to assess the potential of the innovations are: the business models of the producers of the innovations, the industry in which these producers operate, the potential success of the innovations, and the implementations for the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands in case one or both of these innovations become successful. The challenges and potential solutions will be analysed on their origin, effects and impact on the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands.

1.2.2. Type of research

According to Verschuren and Doorewaard a research can be distinguished in two ways, a theory-oriented research and a practice-oriented research. This research falls under the latter since it complies with the following statement by Verschuren and Doorewaard: *'Practice-oriented research is meant to provide knowledge and information that can contribute to a successful intervention in order to change an existing situation'*. A practice-oriented research deals with five stages of the intervention cycle: problem finding, diagnosis, design, change and evaluation

(Verschuren & Doorewaard, 2010). This research follows this intervention cycle for each innovation and future development that is analysed.

1.2.3. Research framework

The research framework of this study is shown below in Figure 5, it provides a clear structure on how the research will be conducted and the steps that need to be taken.

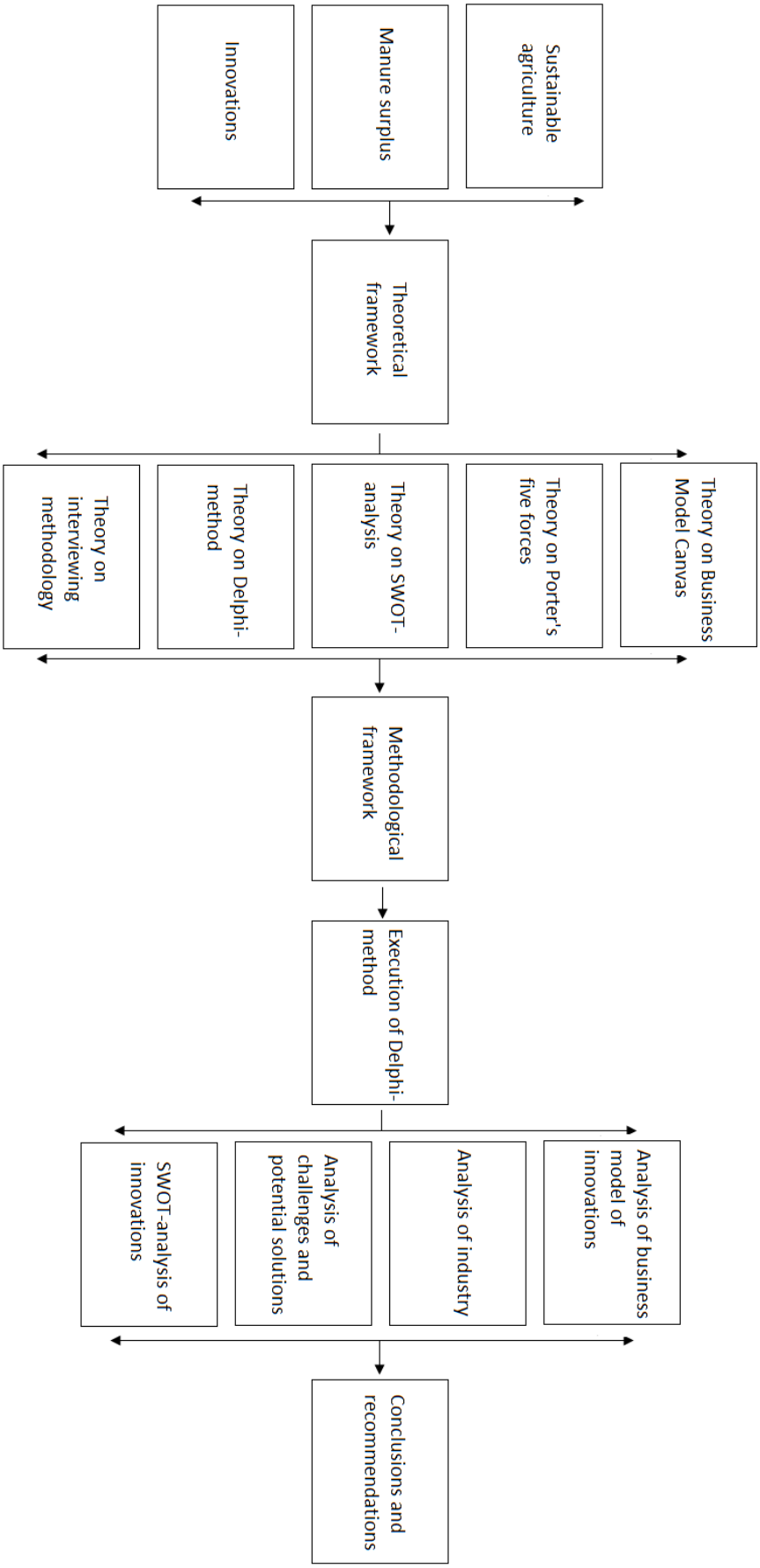

Figure 5: Research Framework

1.2.4. Research questions

In this paragraph the research questions are defined. The central research question for this research is: **What might be the impact of the spoked-wheel fertilizer and the disc-injection fertilizer the dairy farms, the fertilizer industry, and the fertilization industry operating in the Netherlands?** In order to answer this research question, the following specific research questions have to be answered:

SRQ 1: Which of the two innovations could become successful in the Dutch dairy chain and thereby help this chain become more sustainable?

- SRQ 1a: Does the spoked-wheel fertilizer meet the required criteria in order to become successful in the Dutch dairy chain and thereby help this chain become more sustainable?
- SRQ 1b: Does the disc-injection fertilizer meet the required criteria in order to become successful in the Dutch dairy chain and thereby help this chain become more sustainable?

SRQ 2: What might be the impact of the spoked-wheel fertilizer and/or the disc-injection fertilizer on Dutch dairy farms and the fertilizer industry and the fertilization industry operating in the Netherlands?

- SRQ 2a: What is the business model of the producers of the spoked-wheel fertilizer and the disc-injection fertilizer?
- SRQ 2b: What impact can be expected on the use of resources in this part of the Dutch dairy chain?
- SRQ 2c: What companies might be affected by these innovations in this part of the Dutch dairy chain?

SRQ 3: What is the effect of the potential solutions on the capability of Dutch dairy farmers to deal with the challenges and regulations they face?

- SRQ 3a: What are the major challenges and regulations for the dairy farms, fertilizer industry, and fertilization industry operating in the Netherlands?
- SRQ 3b: What solutions might become available to deal with these challenges?
- SRQ 3c: What is the potential impact of these solutions on the Dutch dairy farmers, the fertilizer industry and the fertilization industry operating in the Netherlands?

1.2.5. Definitions of concepts and operationalization

In this paragraph the concepts that are previously mentioned will be defined and operationalized.

Dutch dairy chain: In this research project, Dutch dairy chain stands for all actors in the chain from the tier 2 suppliers to the end customers of dairy farms. This range is graphically indicated by the rectangle in Figure 6 below. The focal company in this case is the dairy farm. For a full description of this chain a literature study can be found in 'Annex 1 The Dutch dairy chain'.

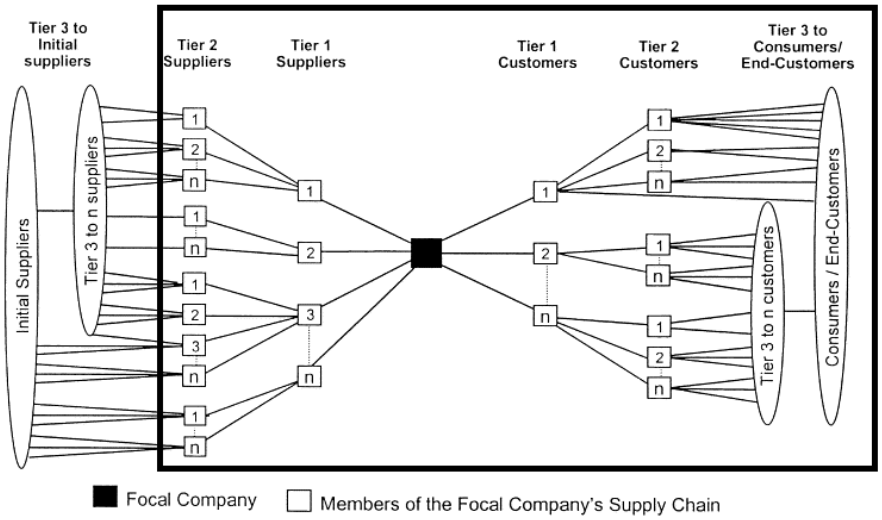

Figure 6: Supply chain (Lambert & Cooper, 2000) adapted with rectangle indicating the scope of the Dutch dairy chain

Fertilizer industry: In this research the fertilizer industry are active in the Dutch dairy chain in the Tier 2 and Tier 1 stage of the suppliers. The fertilizer industry includes the fertilizer producers and fertilizer suppliers. The fertilizer suppliers in the Netherlands are often also the feed suppliers of the dairy farms.

Fertilization industry: When the fertilization industry is mentioned it addresses the following suppliers for the Dutch dairy farms: The producers of fertilizer equipment (Tier 2 and 3), the dealers in fertilizer equipment (Tier 1 and 2), and the contractors who apply the fertilizer on the land of dairy farms (Tier 1).

1.3. Research strategy

The research strategy for this project is in fact a case study after the development of smart fertilization, scrutinized by addressing two machines out of this particular subject. In addition to this case the challenges and potential soluitons in the Dutch dairy chain are subject of this research. The research will be conducted in-depth and in qualitative manner by the means of both empirical and desk research. The data for this study will be gathered via the Delphi method, this method will be further elaborated on in chapter 3 'Methodology'. After the Delphi study is conducted, the data will be analysed on the aspects and by the methods that are listed below:

- Business model of fertilizer injector producers
    - Business Model Canvas (BMC)
- Industry analysis
    - Porter's five forces
- Challenges and potential solutions
- Analysis of the innovations
    - Strengths, Weaknesses, Opportunities, and Threats – analysis (SWOT-analysis)
    - Threats, Opportunities, Weaknesses, and Strengths – matrix (TOWS-matrix)

2. Theoretical Framework

2.1. Sustainable agriculture

The Dutch agricultural sector is one of the leaders in sustainable agriculture, according to the secretary of economic affairs, Sharon Dijksma, the Dutch agricultural sector holds "expertise on efficiency, sustainable production, improved logistics and safe food-processing". Sustainable agriculture is required to increase the global food security (Rijksoverheid, 2013). An example of a method to increase the sustainability in the agricultural sector is the so-called 'climate smart agriculture'. Climate smart agriculture implies that the agricultural sector "produces more food on the same amount of farmland, while the sector adapts to the consequences of climate change and produces less greenhouse gasses themselves", says Sharon Dijksma, the Dutch agricultural sector is a forefront on climate smart agriculture (Rijksoverheid, 2013). The Dutch dairy sector is no exception and is very pro-active in increasing the sustainability in the sector. The 'Sustainable Dairy Chain' is the proof of this pro-active approach of increasing sustainability in the Dutch dairy sector. The Sustainable Dairy Chain is an initiative through which dairy processors (branch organisation Nederlands Zuivel Organisatie) and dairy farmers (branch organisation Land- en Tuinbouw Organisatie) work together to improve the sustainability in order to make the sector future-proof and responsible (Duurzame Zuivelketen, 2015). The Sustainable Dairy Chain has formulated the following general goals for 2020 (Duurzame Zuivelketen, 2015):

- Development towards climate neutrality
- Continuous improvements in livestock health and welfare
- Preservation of grazing
- Protecting biodiversity and the environment

The current situation in the trajectory of achieving these goals varies in success. In the sector-report of Reijs et al. the performances on each goal are measured and analysed (2014):

For the development towards climate neutrality the performance of the sector has improved on energy efficiency, but for greenhouse gas emissions the performance was worse: Significantly more dairy farms installed installations for generating renewable energy, such as; Solar panels, heat recovery, and heat pumps. This resulted of increase in energy efficiency of 5.3% in 2013 in comparison with 2011. For the future Ruitenberg and Jacobs expect that all Dutch dairy farms up to an annual milk-production of 2-2.2 million kilograms of milk can become self-sufficient in electricity by means of solar panels, with a bio-gas installation or a windmill the larger dairy farms should also be able to become self-sufficient in electricity (Reijs, et al., 2014).The CO_2 –equivalents (greenhouse-gasses) per kilogram milk remained the same in 2013 at 1.27 kilogram, however, in comparison with 2012, the total milk-production increased by 4.6% and thereby also the total emission of CO_2 –equivalents grew with 4% (not 4.6% because dairy processors reduced their emissions slightly). The goal of the Sustainable Dairy Chain, but also of the 'Energy-Agreement' (Energie-Akkoord), is to reduce 20% of the total emission of the Dutch dairy chain in comparison with 1990. The current level is at 19% reduction, this implies that without growth of the sector a small reduction would achieve the goal, however growth of the sector is expected. In theory large reductions are still possible: Van den Pol-Dasselaar et al. estimate that changes in operating dairy farms have a 'reduction-potential' of 1-2 Mton CO_2 –equivalents (2013). Rougoor et al. estimate even more reduction-potential when manure-processing is also taken into account; 2.5 Mton CO_2 –equivalents (2013). Besides optimizing the operating of businesses, a major change towards sustainable energy can also cause a large reduction of CO_2 –equivalents: 1.9 Mton according to Krebbekx et al. (2011). Despite all this (theoretical) potential for reduction, the authors of the

sector-report expect realisation of reduction to be hard because of the stability of the emission-levels the past years (Reijs, et al., 2014).

For the continuous improvements in livestock health and welfare the reduction of the use of antibiotics is one of the major subjects. In 2013 slightly less antibiotics were used in comparison with the year before; 2.8 Defined Daily Dose Animal (DDDA) compared to 2.9 DDDA in 2012. The DDDA gives a comparable figure for the dosing of antibiotics, based on the supplied antibiotics and the amount of kilograms of treatable cattle on a yearly basis. An important aspect of the comparison between 2012 and 2013 is that hardly any antibiotics of the third category were used; the third category holds the antibiotics that are vital for the humane sector and to prevent resistant bacteria for these antibiotics it is important that the use of these antibiotics on livestock is reduced to a minimum. Another major subject of the general goal of continuous improvements in livestock health and welfare is the prolonging of the lifetime of dairy cattle. The three major reasons for culling cows are poor fertility, hoof-problems, and problems with udder-health (Gosselink, et al., 2009). Besides that fighting the abovementioned reasons for culling will increase the lifetime of dairy cattle, it also directly improves the animal health and welfare in general. In comparison with 2012 the lifetime of dairy cows stabilized with a minor increase in 2013; from 5 years and 8.8 months to 5 years and 9 months. The future goal that was set by Sustainable Dairy Chain is to achieve 6 months longer lifetime of cows in 2020 compared to 2011. Sustainable housing is another major aspect within the main goal of improving livestock health and welfare. Sustainable housing is housing which distinguishes from regular cow-housing based on improved animal-welfare: The Sustainable Dairy Chain distinguishes four types of housing that are 'sustainable housing': Housing with the 'Maatlat Duurzame Veehouderij'-certificate, organic dairy farms, housing with the 'Integraal Duurzame Stallen en Houderijsystemen' investment-scheme, and housing that meet the requirements of the 'Beter Leven'-mark. On the first of January 2014 5.8% of the housing of dairy cattle was sustainable, an increase of 3.3% since 2011 (Van der Peet, et al., 2014). In the future the Sustainable Dairy Chain will develop a new monitoring system and a score for animal welfare, enabling them, and the whole sector, to express the welfare of the dairy cattle on a scale. This monitoring system and welfare-score will be used no later than 2017 (Reijs, et al., 2014).

Another goal of the Sustainable Dairy Chain is the preservation of grazing. The organization aims for maintaining the same amount of dairy farms applying grazing on their farm as in 2012. This level was 72.2% in 2013, however, in the reference year 2012 this level was 73.6%. This are the levels of grazing according to the definition of 'Stichting Weidegang': Dairy farms which graze their cows at least 120 days for 6 hours per day. Despite not maintaining the level of grazing one year after the reference year, the goal of Sustainable Dairy Chain remains the same. A covenant with the same goal regarding grazing as Sustainable Dairy Chain was signed by dairy farmer organizations, dairy processors, suppliers of dairy farms, retailers, cheese-traders, social organizations, government, nature conservation organizations, education and science. Every party that signed this covenant will pursue an increasing in grazing in the dairy sector. Each party will have its own way of stimulating this. For example, in 2013 6 dairy processors offered a premium per kilogram milk if grazing was applied on that specific dairy farm. Last January, FrieslandCampina doubled their premium from €0,50 to €1,00 per 100 kilogram milk in order to stimulate the grazing level even further (Hogenkamp, 2014).

The last general goal that was stated by Sustainable Dairy Chain is protecting biodiversity and the environment. The first of the major subjects in this goal is the use of sustainable soya in the dairy sector. The goal on this specific subject was to reach a 100% use of sustainable soya in the dairy sector in 2015. This goal is shared by a lot of institutions and an intention-statement was signed by companies such as parties active in the soya-processing and trade, the feed-sector, the

livestock-sector, processors of product from the livestock sector, and the retail-sector. The social organisations 'Natuur en Milieu', Solidaridad, and the WWF also signed this statement. The intention-statement however did not just apply on the dairy sector but on the whole livestock-sector. In 2013 29% of the soya that was used in the dairy sector was sustainable. According to Sharon Dijksma, secretary of economic affairs, the goal of Sustainable Dairy Chain was reached, however, the goal for the whole livestock sector was not reached since only the dairy chain reached a 100% use of sustainable soya in 2015 (Vermaas, 2015). Reducing the amount of phosphate and the ammonia-emission is also an important part of protecting the biodiversity and the environment. The most recent development on this subject is of course the announcement of phosphate-rights. As stated in the introduction of this research the Dutch government saw themselves forced to interfere because the sector could not remain under the ceiling that was set at 84.9 in the plan for the dairy sector of NZO and LTO in 2013 (Rijksoverheid, 2015). The exact implications of the phosphate rights remain unclear, but it is sure to be restricting the dairy sector in the production of phosphate and thereby in growth (MKB-adviseurs, 2015). The emission of ammonia from dairy-manure has been greatly reduced since 1990, from 162 million kilograms in 1990 to 49 million kilograms in 2013, however, when the emission of 2013 is compared with the emission in 2012 it is 3 million kilograms higher due to an increase in dairy cattle. The goal of the Sustainable Dairy Chain is to reduce ammonia-emission with 5 million kilogram relative to reference year 2011 in which the total ammonia-emission from dairy-manure was 50 million kilograms. In the two years since the reference year, the Dutch dairy sector has realized a reduction of 0.9 million kilogram ammonia-emission. Rougoor et al. studied the potential reduction by efficiency-improvements on the dairy farm, their conclusion was that a reduction of phosphate-excretion of 11 million kilogram on reference year 2011 could be realized. 3 million kilogram of this reduction in phosphate-excretion comes forth out of increasing the mineral efficiency of the soil and crops from 82% to 95%, this would also reduce ammonia-emission with 1 million kilogram and the emission of CO_2-equivalents with 4 million kilograms (Rougoor, et al., 2013).

2.2. Manure surplus

Another issue that the dairy sector and the Dutch government have to deal with is the growing manure surplus that has been developing over many years. Currently, no less than 78% of the specialized dairy farms has to deal with a manure surplus (Statline, 2014). This implies that 78% of the specialized dairy farms produces more minerals than they can apply on their fields. At this moment several laws have been or will be introduced by the Dutch government in order to deal with the manure (and phosphate-) surplus :

- The manure-processing obligation
- Land-based growth of dairy farms
- Phosphate rights

The manure-processing obligation was introduced on the first of January 2014. For dairy farmers it means that in case they have a manure surplus, a part of their surplus has to be processed. A part of this processed manure can be transported to foreign countries where a demand for manure exists. This part differs per region in The Netherlands; The dairy farms in the South have to process 50% of their manure surplus, The dairy farms in the East 30%, and the dairy farms in all other regions in the Netherlands 10% (RVO, 2015). When the manure that has to be processed of a specific farm does not add up to a 100 kilogram phosphate or more, this farm is exempt from the obligation (RVO, 2014). The dairy farmers can process the manure themselves with a hygienisation-unit, or have a third party with such a unit doing it for them. Another option is to burn the manure in order to generate energy from it (Rijksoverheid, 2015).

The land-based growth of dairy farms, as described in the introduction of this research, restricts the growth of dairy farms based on the phosphate surplus they will have in the new situation after their growth. The size of the phosphate surplus determines what steps have to be taken by the dairy farm (Rijksoverheid, 2015):

- A phosphate-surplus of <20 Kg per hectare; the farmer can choose to purchase extra land for the surplus or to process the surplus.
- A phosphate-surplus of 20-50 Kg per hectare; the farmer has to purchase land to create room for 25% of the phosphate gained through the growth of the farm.
- A phosphate-surplus of >50 Kg per hectare; the farmers has to purchase land to create room for 50% of the phosphate gained through the growth of the farm.

This restriction will be introduced on the first of January 2016, but already accounts for growth of dairy farms in 2015 (Rijksoverheid, 2015).

The latest restriction that was announced are the phosphate rights, also already discussed in the introduction of this research. While the phosphate rights are meant to restrict or even reduce the phosphate production, it directly has its effect on the manure-surplus. Due to the phosphate rights the manure surplus will not grow as much as predicted because the number of cows (and thereby the amount of manure) can only grow in case of an increase in phosphate efficiency. Another positive impact of phosphate rights on the manure surplus is the enlarged chance for the Dutch government of prolonging the derogation: When the Dutch dairy sector no longer exceeds the phosphate-ceiling of 84.9 million Kg, the European Union is expected to be more positive towards prolonging derogation for the Dutch dairy sector (Rijksoverheid, 2015) (Rijksoverheid, 2015). Derogation is an exception on the European manure legislation. When a Dutch dairy farmer meets the conditions that are set, he or she is allowed to apply more manure on their fields: Instead of 170 Kg nitrogen per hectare 250 Kg of nitrogen per hectare can be applied, with an exception for sand- and loess-fields in Overijssel, Gelderland, Utrecht, Noord-Brabant and Limburg, on these fields the limit is 230 Kg of nitrogen per hectare in case of derogation. The conditions that a dairy farmer has to meet in order to be eligible for derogation are (RVO, 2015):

- 80% of their farmland is grassland
- A fertilization plan is designed for the coming year before the first of February
- The farmland has to be analysed on phosphate-condition and nitrogen-supplying capacity
- No phosphate from artificial fertilizer is used

For the dairy sector and the Dutch government it is of outmost importance to have the derogation prolonged by the European Union, because otherwise the manure surplus will increase largely.

2.2.1. Solutions

Several solutions that deal with the manure surplus, the phosphate surplus, the greenhouse gas emissions of manure and fertilizer, and the announced restrictions are currently applied and developed.

2.2.1.1. Processing manure into mineral concentrate

One of these solutions is processing manure in such a way that a part of it can be applied instead of artificial fertilizer. Multiple initiatives and studies have been and are executed to process manure into a mineral-concentrate, an example of such a study is the method developed by Starmans and Timmerman from Wageningen UR Livestock Research: The method they developed works with two barrels, in barrel 1 the ammonia is separated from the thin manure with a high amount of ammonium, the ammonia is brought to the second barrel which contains sulphuric acid.

The sulphuric acid binds the ammonia and this process results in ammonium-sulphate with 18% nitrogen, which is suitable for fertilization (Van der Vegte & Starmans, 2013). Already in 2008 the Dutch government started 10 pilots for manure refinery in order to gain mineral-concentrates that could serve as fertilizer (Verburg, 2008). Despite these pilots and all the other studies, currently there is not one method that allows a part of the manure to be used instead of artificial fertilizer. However, secretary of economic affairs Sharon Dijksma aims at changing this: She plans to increase the applications of mineral-concentrate via a change in the European frameworks by emphasising the circular economy, by enlarging the pilot of mineral-concentrate, and by increasing the derogation of the nitrates-directive (Dijksma, 2015).

2.2.1.2. Acidification of manure

Acidification of manure by adding bacteria to reduce the emission of ammonia is a solution that is currently being studied. First results of a study by Bussink et al. (2012) show that a reduction of the pH of manure to 5.5 reduces the ammonia emission significantly: A reduction of ammonia-emission from manure can be realized in 3 stages;

- 35% reduction from the emission out of the cattle-housing
- 90% reduction from the emission out of the (separate) manure-storage
- 85% reduction from the emission that occurs with applying the manure on the field

The researchers also state that the total reduction depends on the soil type; 54% for sand, 59% for clay, and 65% for peat. When the pH is reduced to 6 instead of 5.5 the reduction of ammonia is logically also less reduced; 35% for sand, 39% for clay, and 44% for peat (Bussink, et al., 2012).

2.2.1.3. Smart Fertilization

Another ongoing development is the concept of 'Smart Fertilization'. Smart Fertilization is the method of applying the right fertilizer, at the right time, with the right amount and at the right place. Smart Fertilization deals with the challenges and developments that the Dutch dairy farmers are facing. It can increase mineral efficiency of several mineral sources: by very precise placing of manure and liquid fertilizer by means of GPS, Smart Fertilization is able to increase the utilization of the minerals in the manure, fertilizer and the soil. This increase in efficiency results in several advantages (Bartlema, 2015):

- The efficiency of the minerals in the legally limited amount of manure is higher
- Less manure has to be discharged due to better overall mineral efficiency
- Crops suffer less from impoverishment of the soil due to the highest potential supply of organic matter from manure
- A higher yield per hectare can be realized

An aspect that would boost the development of smart fertilization largely is site-specific placement of manure and fertilizer. The site-specific application of fertilizer is technologically already possible for the greenkeeper of sports-fields, therefore the development of the machines that can apply fertilizer and manure site-specific does not seem to be a large challenge (Raats, 2012). The site-specific determination of the demand of the soil, grass, and maize (the two most common crops in the dairy sector) however is more complicated. A study by Hoving et al. (2014) describes that the current sensor-technology is not developed far enough to provide the farmer or the machine with the site-specific mineral-demand of the soil and/or crop, however, these sensor-technologies receive a lot of attention and therefore are expected for the medium term of 3-7 years from now, state Hoving et al. in their study (2014).

2.3. Introduction of innovations

This research further scrutinizes the smart fertilization development, and in particular the smart fertilization of artificial fertilizer. The reason for this distinction is because for the applying of fertilizer several 'smart fertilizers' have already been developed and therefore can be scrutinized. Since current the current derogation on manure legislation has the condition of 80% grassland, the most relevant study is after the application of artificial fertilizer on grassland. In this section the fertilization on grassland, liquid fertilizers, and the innovations that will be the subject of this study will be introduced.

2.3.1.1. Fertilizer on grassland

Fertilizer plays an important role in increasing the grass production. In general there are three types of fertilizer; manure, solid granulates and liquid fertilizer. The manure is produced by animals, whereas the granulates and liquid fertilizer are produced or obtained from other industries. Traditionally the granulates are broadcasted across the field. However, during the past years liquid fertilizer has emerged as (sustainable) substitute. Liquid fertilizer can be applied to the field in several ways; it can be sprayed on top of the field or it can be injected into the root-zone of the grass directly. The downside of spraying is the larger risk for emission and leaf burning (Hoefman, 2011). Therefore, injecting liquid fertilizer is the more sustainable method of application. However, there is very contradictive information regarding the best methods and means for applying fertilizer on grassland which emphasises research amongst experts on this subject.

The injection of the fertilizer results in a reduction of emission and leeching. Due to the GPS-system the field can be fertilized exactly from side to side and overlap can be reduced to a minimum due to separately closable sections (Boerenbusiness, 2014). This in contrast with traditional fertilizer spreading, where dry granulates of fertilizer are broadcasted which complicates the spreading near ditches and headlands of the field (Triferto, 2015 (a)). In the table below an example of a benefit and cost analysis is given for a year production of grass, a lot of variable benefits cannot be filled in because these are very company-specific. This example is merely an indication of the potential benefits and costs of this method of application.

Table 1: Cost benefit analysis N20 (blowdown-lye + Urean) vs traditional fertilizer (SFO, 2014)

Type of benefits/costs	*Elaboration*	*Result*
Fixed benefits/ha		
- Increased grass production	3% of 11.000 Kg dry matter (€150/1.000Kg)	€49.50
-Savings fertilizer	15% of 200Kg N (€1/Kg N)	€30.00
-Savings traditional spreading		€20.00
	Sub-total	**€99.50**
Variable benefits/ha		
- Exact side to side fertilization	5-15% of 11.000 Kg dry matter	€82.50
-Increased manure placement	company-specific	
- Increased application of organic matter	company-specific	
- Savings for Sulphur	company-specific	
	Sub-total	**€82.50**
	Total benefits	**€182.00**
Cost/ha		
-Contractor	€50/ha	€50.00
-Extra costs due to acidifying effect	Liming more often	€35.00
	Total cost	**€85.00**
Total benefits-cost		**€97.00**

1.1.1.1. Liquid fertilizers

The fertilizer that is used in this example is blowdown-lye in combination with Urean. Blowdown-lye is the residue that is chemically filtered out of the air by air scrubbers which are for example placed on pig stables. The ammonia-containing air is led through a sulphuric acid which results in clean air and Blowdown-lye. This waste-stream of Blowdown-lye is a registered form of fertilizer and contains a ammonium-sulphate-solution (N+S solution). Blowdown-lye holds almost no phosphate and therefore it is allowed as a sulphurous nitrogen-fertilizer and also applicable for derogation-farmers as long as its phosphate content is less than 0.5% (WUR, 2009). The downside of Blowdown-lye is that its contents differentiate. It holds between 1%-6% Nitrogen and between 4%-20% sulphur-trioxide. The amount of sulphur will be approximately 3 times as much as the amount of nitrogen (WUR, 2009). Therefore, it cannot be used throughout the year, it is very suitable to be applied during spring (Bussink, 2014). Another important aspect of blowdown-lye is its acidity, when it is used the soil acidifies faster than with other fertilizers and therefore lime has to be applied more often on the field (Bartlema, 2015), (WUR, 2009). Urean is the most used liquid nitrogen-fertilizer (Agripress, 2011). It is a 50-50 mix of ammonium-nitrate and urea. Urean contains 30% nitrogen in three forms; urea-nitrogen (15%), ammonium-nitrogen (7.5%) and nitrate-nitrogen (7.5%) (Triferto, 2015 (b)), (OCI Nitrogen, 2015). The table below provides an

overview of the most used fertilizer in the Netherlands (KAS) and liquid alternatives with an indication of their characteristics.

Table 2: Fertilizers and their characteristics (Van Well, 2014), (DSM Agro, 2010), (Rensen, et al., 2011), (Van Schooten, 2009) (CZAV, 2015), (Triferto, 2015 (a)), (NutriNorm, 2015), (N-xt, 2015), (CLM, 2014), (de Haas & van Dijk, 2010)

	Blowdown-lye	**Urean**	**Anasol**	**NTS**	**Urea**	**Calcium Ammonium Nitrate**
Form	Liquid	Liquid	Liquid	Liquid	Liquid	Granulates
Price/kgN	€0.60	€0.83	€0.80	€0.85	€1.00	€1.00-€1.20
Compounds	1-6% NH_4 4-20% SO_3	15% $CO(NH_2)_2$ 7.5% NO_3 7.5% NH_4	9.5% NH_4 5.5% NO_3 8% SO_3	13% $CO(NH_2)_2$ 7.5% NH_4 6.5% NO_3 7.5% SO_3	22% $CO(NH_2)_2$	13.5% NH_4 13.5% NO_3
Availability for plant	Slow	Mostly slow	Slow and fast	Mostly slow	Slow	Slow and fast
Acidifying effect	Very high	High	Very high	Normal	High	Normal
N-losses (emission/ leeching)	Very low	High	High	Normal	Very high	Low
CO_2 footprint	None	Low	Low	Low	Normal	Normal

The characteristics in the tables are indications because information was often contradictive. The prices per kilogram N are true for different years and different suppliers, therefore, these are hard to compare. The CO_2 footprint of blowdown-lye is very low because it is not fabricated, it is after all a waste-stream, the only CO_2 that is generated is by transport and potentially a treatment, which would be also done in case it was not used as fertilizer. NO_3 (nitrate-nitrogen) is directly available and hence the fastest nitrogen, NH_4 (ammonium-nitrogen) is first adapted in the micro-organisms and will gradually become available for the plant. $CO(NH_2)_2$ (amide-nitrogen) is the slowest available, this form of nitrogen is first converted to ammonium-nitrogen by the enzyme urease (DSM Agro, 2010).

1.1.1.2. Liquid fertilizer injectors

The two methods of applying fertilizer on grassland that will be focussed on in this study are the recently introduced disc injection system and the more common spoked-wheel fertilizer. The reason to focus on these two liquid fertilizer injectors is that it are the only two injection methods that are known to be in practice in the Dutch dairy sector. These liquid fertilizer injectors are often used by contractors who apply the liquid fertilizer for the dairy farmers. This is in contrast with

the traditional fertilizer spreading, which is mostly done 'in-house' by the dairy farmers (Van Schooten, 2009).

1.1.1.2.1. Disc injection fertilizer

The disc injection fertilizer is shown in Figure 7 below. The discs make small incisions in the soil with a depth of 5-7 centimetres (the root-zone of grass), the liquid fertilizer is injected in these incisions (Bartlema, 2014). This disc injection fertilizer, as it is shown in this figure, is not yet produced for commercialisation, this machine was build and is applied by contractor Slingerland and Van Den Berg. The machine is solely meant for grassland purposes and the frame and elements are from a second-hand Vredo grassland slurry-injector. The working width of this machine is 10.40 metres, and has 52 coulters, one coulter every 20 centimetre (Boerenbusiness, 2014).

Figure 7: Disc injection fertilizer (Boerenbusiness, 2014)

The machine is guided by gps (rtk-gps) and holds the ability to close each of the 6 sections individually based on the gps data. The tank for the liquid fertilizer is in this case installed on the front of the tractor and holds a 1000 litre, this is relatively small but necessary since this machine is operated in a very rutting-sensitive area in The Netherlands. The building of this machine was at the expense of approximately 50.000 euro for the contractor, the gps-controlled section closure is the most expensive part of the cost that were made in order to develop this machine. Slingerland and Van Den Berg charge 35 euros per hectare for fertilizing grassland with the disc-injection fertilizer (Boerenbusiness, 2014). An important aspect of this machine are the roll-pumps which are placed in the centre of the machine. In Figure 8 a roll-pump is schematically shown, the white drive shaft is driven by the tractor, the rolls on this shaft press the tube at one point and as the shaft turns a vacuum is created. These pumps are able to pump the right amount of fertilizer to the elements independent of the driving speed. The pumps require very little maintenance and are not harmed by the acidifying fertilizers since the pumps are on the outside of the tubes and therefore do not contact the fertilizer directly.

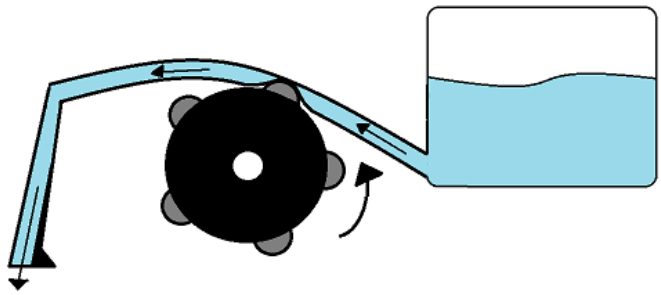

Figure 8: Schematic overview roll-pump

1.1.1.2.2. Spoked-wheel fertilizer

The other Smart Fertilizer that will be taken into account in this study is the spoked-wheel fertilizer. This fertilizer is more common compared to the disc injection fertilizer. The goals of both fertilizers are the same; applying fertilizer in the rootzone with minimal losses. As Figure 9 below shows the method of application is different. The spokes enter the ground every 18 centimetres to inject the fertilizer at 5-10 centimetres depth under light pressure (Triferto, 2015 (c)), (Boerenbusiness, 2014).

Figure 9: Spoked-wheel fertilizer (Gemeren, 2015)

For the description of this fertilizer the spoked-wheel fertilizer of manufacturer Duport is used. This manufacturer delivers spoked-wheel fertilizers with a working-width varying from 4.5 up to 12 metres. The sections can be closed separately, which can also be controlled by gps. The injection-wheels are placed every 25 centimetres and equipped with stainless steel spokes of 8 centimetres. The heavy spring arms press on each wheel individually, causing every spoke to be firmly pressed into the soil. This machine can spread 150-1500 litres per hectare on grassland, but also on arable land. Below a table is shown of the embodiments (without tank) that can be delivered by this manufacturer (Duport, 2015).

Table 3: Duport spoked-wheel fertilizers (Duport, 2015)

	SW4518	*SW6024*	*SW8032*	*SW12048*
Working width (m)	4.50	6.00	8.00	12.00
# injection wheels	18	24	32	48
Weight	1000	1300	1700	2240
Sections	3	3	3	5

A downside of the spoked-wheel fertilizer is the durability of the spokes, these are said to wear down relatively fast. The investment cost for a 12 metre Duport spoked-wheel fertilizer, including 8,5 m^3 tank, is estimated at €110.000 (Mestrom, 2008).

Another large manufacturer of spoked-wheel fertilizers is Güstrower, the systems are very similar compared to those of Duport. Güstrower manufactures spoked-wheel fertilizers with a working width of 3, 6, 12 and 15 metres and respectively 1,3,4 and 6 separate (gps-controllable) sections (Gemeren, 2015).

Further price-indications cannot be given since the regarding companies would not provide these because of competitive information.

3. Methodology

This chapter describes the method of data-collection and data-analysis that have been executed during this study.

3.1. Method of data-collection

The empirical part of this thesis will be executed by a Delphi-study. In this section an elaboration of this method will be formulated. In addition to that the design of the Delphi-study for this specific research will be provided. For a more extended literature study after the Delphi-method see 'Annex 2 The Delphi method'.

In order to acquire a good vision on the business model, industry and potential impact of an innovation without actually possessing all the factual information on the innovation, experts have to assess the innovation from the different angles of their expertise. In this way an estimation of all the information that is needed for the analysis, and that is not known yet, can be made. The people who already worked with a prototype or even the final product can be addressed, but also the potential users of the innovation, the Dutch dairy farmers, can give their opinion on the potential of the innovation. These 'experts' can be divided into two groups. The people that already worked with the product or a prototype of it analyse the product in retrospect whereas the people who might work with the product in the future perform a use-analysis in prospect (Nelson, et al., 2013).

To analyse the business model, industry and potential impact of the innovations, experts from different fields and backgrounds have to analyse the innovation and provide a judgement. An overall conclusion on the potential of the innovations is necessary and for that reason the Delphi method is applicable for this research. In a study after the the current validity of the Delphi method Landeta states: *´The Delphi method is a popular technique for forecasting and an aid in decision-making based on the opinions of experts, which has been in existence for over half a century'.* In this study he concludes that the Delphi method still is a valid instrument for forecasting and supporting decision-making (Landeta, 2006). The Delphi method aims at obtaining and defining a group judgement. Often experts come with different conclusions when asked to analyse the same subject, especially when these experts have different backgrounds. The Delphi method is a research method that aims at gaining consensus regarding the subject between the participating experts (Okoli & Pawlowski, 2004). This consensus is reached by several rounds of interviews with the same experts. However, Turoff has described another purpose of the Delphi study for cases were consensus simply will not be achieved due to the strongly different viewpoints. In his study he describes the design of a 'policy Delphi' opposed to the common Delphi also known as the 'technological Delphi', the goal of this Delphi method differs: *"Its goal in this function is not so much to obtain a consensus as it is to establish all the differing positions advocated and the principal pro and con arguments for those positions."* (Turoff, 1970). According to Dalkey, the founder of the Delphi method in the 1950's, there are 3 important features that are characteristic for the Delphi method:

- Anonymous response
- Controlled feedback
- Statistical group response

All experts remain anonymous throughout the process, the opinions are gathered via a formal questionnaire. Between all rounds the results of the previous round is summarized and communicated back to all participants, this reduces *noise.* When the questions involve estimations

of numbers, the statistical group response is a convenient instrument to take into account all the answers. In this way all experts feel appreciated, and, maybe even more importantly, further analysis becomes more accurate (Dalkey, 1969). This increase in accuracy is endorsed by Landeta: '*The average consensus in the second round was greater than in the first. The average typical deviation of the different distributions from the first round was 3.35, while it was 2.43 in the second round*' (2006). A critique on the Delphi method of course is that it does not rely on factual information but on intuitive insights and therefore it is not as reliable as concrete measurements (Pill, 1971). On the other hand, waiting until concrete measurements can be obtained is not always an option, as is the case in this research. A strength and at the same time a weakness of the method lies in the group judgement, Pill clarifies this as follows: 'I*t is undoubtedly true that a group has more total expertise than any of its members, but it also dilutes the opinion of the real expert on the particular question that is being considered*' (1971). A point of critique pointed out by Rowe and Wright is the lack of specific instructions on the role of feedback. In their study is mentioned that the Delphi method requires more structured guidelines to be used to its full potential (1999). The Delphi method can be used for qualitative, quantitative and mixed research models according to Skulmoski et al. In the same study the authors warn for the use of heterogeneous samples since these can greatly increase the complexity of the results. This will also cause it to be much harder to reach consensus amongst the panel (2007). Turoff however states that the respondent group should be as heterogeneous as possible, because: *"The use of a heterogeneous group is the best way to stimulate a systematic exploration of all the pros and cons on specific resolutions"* (1970). In several studies it is stressed to bear in mind that if a researcher chooses to use the Delphi method a great deal of the responsibility for success of this method lies with the researcher and the execution of the Delphi method (Rowe & Wright, 1999), (Skulmoski, et al., 2007), (Okoli & Pawlowski, 2004).

3.1.1. The application

The application of the Delphi method in this thesis is described in this section. The aim of this study is to get a sound future vision on the potential impact of the innovations and on the challenges and potential solutions in the Dutch dairy chain, therefore, the goal is not so much to gain full consensus on all topics, but mainly to gain the relevant perspectives from all the relevant angles in the Dutch dairy chain. For the potential impact of the innovations a 'technological Delphi' was most suitable, whereas for the challenges and potential solutions the 'policy Delphi' provides the most relevant insights. This means a combination of Turoff's design, and Okoli and Pawlowski's design was applied in this research; consensus was sought for, but as soon as it seemed unlikely to be achieved, the focus moved to bringing the different views and the reasons behind these views to light. The latter mostly occurred for the challenges and potential solutions in the Dutch dairy chain since the views on these developments differed strongly. The respondents within the different panels are as heterogeneous as was practical for this research in order to cover all the relevant angles. Because the design of a policy Delphi usually has four to five rounds and asks respondents merely to rate options and then elaborate or comment on the choice, this design was not fully applicable within this study. For the 'panel creation process' the example of Okoli and Pawlowski was used. The first step in this process is creating a Knowledge Resource Nomination Worksheet (KRNW), the KRNW for this study can be found in 'Annex 3 KRNW'. The KRNW was used in order to develop the panels (Okoli & Pawlowski, 2004). According to Paliwoda a Delphi study can have up to four panels per subject with a panel-size of at least 10 members per panel (1983). Within this research each panel exists out of 10 experts.

This Delphi study was executed in two rounds, in some cases a third round was executed by means of a phone call to gain full understanding of the answers given during the second round. With the

first round aspects of any importance regarding the innovations were gathered as many as possible. Also, the respondents gave their vision on what challenges await the Dutch dairy chain. After the first round was executed all aspects were processed into listings per subject. In case of consensus on a particular subject, the subject was left out of the second round, in case of polarization on a certain subject, Turoff's example was followed: *"When a polarization of views occurs, we will tempt to develop questions designed to highlight reasons for the polarization"* (1970). After the processing of the data of the first round was finished, the second round was started. During this second round the respondents reacted and shared their vision on challenges and potential solutions that were described by respondents during the first round. Also, two experts were added to the respondents group. These respondents have a lot of expertise on a specific subject of relevance based on the results of the first round. When the second round was finalized, some ambiguities arose during the processing of the data gathered during this second round. These ambiguities were clarified by the respondents via a phone call. When all the data was processed and in some cases clarified, the data was ready to be used for the analyses.

The innovations, challenges and potential solutions have been reviewed and analysed by 3 panels. In total 32 experts participated in this research; for each panel 10 experts were solicited, 10 for the practitioner panel, 10 for the Dutch dairy chain panel and 10 for the smart fertilization panel. In addition to that, the two experts that were added for their expertise on specific topics after the first round accumulate to a total of 32 respondents.

3.1.1.1. Smart fertilization experts panel

This panel is assembled with respondents who are specialized in the domain of the smart fertilization. The panel has been able to use their specialized point of view in order to assess the business model, industry and potential impact of the innovations based on domain-specific properties. Besides this, the experts have very specialized visions on the potential solutions regarding smart fertilization. The smart fertilization experts were given the codes 1A – 1J.

The selection criteria that have been used for soliciting the smart fertilization experts panel are the following: The profession of the respondents is directly related to smart fertilization and their knowledge on smart fertilization has been proven by previous achievements on the subject, such as: produced machines, developed machines, sales of machines, scientific articles, branch literature, projects, and/or presentations. When a respondent recommended another expert a background check of this potential respondent was executed before he or she was approached. For the smart fertilization panel a mix of the following backgrounds of respondents was aimed for:

- (Smart) Fertilizer machine developer/producer
- Scientists with expertise on; smart fertilization, agro-systems, forage (grassland) production, soil management, nutrient flows.
- Fertilizer suppliers
- Fertilizer producers
- Agricultural NGO-representatives
- Branch-media

The actual panel contained experts from all of the abovementioned backgrounds, except for the background of fertilizer producer.

3.1.1.2. Practitioner panel

For the practitioner panel 10 entrepreneurs have been solicited who can be considered as belonging to the (future) target group of the innovations. A panel of 10 practitioners is in place, this panel exists out of 5 dairy farmers and 5 contractors. These panels were in the position to assess the potential of the innovations and the impact of challenges and solutions due to their experienced and practical point of view. The experts are all coded with a number and a letter. The number stands for the type of panel and the letter stands for the expert in that panel. The contractors were given the codes 2A – 2E and the dairy farmers 3A-3E.

The selection criteria for the contractors were the following; the respondent (partially) owns an agricultural contracting business and uses one of the innovations that are subject of this research. The selection criteria for the dairy farmers is; the respondent owns and operates a dairy farm.

3.1.1.3. Dutch dairy chain experts panel

For this panel respondents with a view on the entire chain were solicited. This panel has a sophisticated view on the business model, the industry, and the potential of the innovations while being very suitable to create insight on the impact of the innovations on the chain. In addition to that their vision on the challenges and the impact of those on the Dutch dairy chain is often very substantiated. The Dutch dairy chain experts were given the codes 4A – 4J.

The selection criteria for the Dutch dairy chain experts panel are the following; the respondents have expertise on several stages within the Dutch dairy chain. The profession of the respondents is directly linked to the Dutch dairy sector. The education level of the respondents is at least 'Higher Professional Education' (HBO). A mix of the following backgrounds was aimed for:

- Dairy processor
- Scientists with expertise on dairy (-chains)
- Teacher in dairy (-chains)
- Dairy accounting
- Agricultural NGO-representatives
- Independent dairy consultancy
- Feed/fertilizer supplier

A expert belonging to an independent dairy consultancy is the only missing background in the Dutch dairy chain experts panel of the abovementioned background.

The two experts who were added after the first round in order to gain extra expertise have the codes 5A and 5B.

The complete overview and backgrounds of the panels can be found in 'Annex 4 Expert panels'.

3.1.1.4. The questionnaire

In this section the questions for the first round will be described and the reason for asking these particular questions will be explained. For the full questionnaire please look in 'Annex 5 Delphi Questionnaire Round 1'

1a: What would you estimate to be the percentage of dairy farmers that will apply smart fertilization for fertilizing their fields? (currently, 2017, 2020, 2025), (lowest estimate, most probable estimate, highest estimate)

This question was asked to gain insight in the current situation and the prospect for smart fertilization. The respondents were asked to give their estimate for most probable estimate, and for the lowest and highest estimate the value of which they thought the true value would certainly be in between. By asking for these lowest and highest estimates the respondents showed how certain they were of their estimate.

1b/1c: What would you estimate to be the percentage of 'spoked-wheel fertilizer'/'disc-injection fertilizer' of all Smart Fertilizers that will be applied? (currently, 2017, 2020, 2025), (lowest estimate, most probable estimate, highest estimate)

These questions were asked to gain insight on how the specific innovations are currently diffused and what the prospects for the innovations are amongst the respondents. Again, the lowest and highest estimates of the respondents showed how certain they were of their estimate.

2: What would you estimate to be the percentage of dairy farmers outsourcing smart fertilization compared to the total of dairy farmers applying smart fertilization (outsourcing + DIY)?

This question provided insight in how much dairy farmers are expected to outsource smart fertilization versus doing it themselves.

3: What would you estimate to be the percentage of liquid fertilizer that is used compared to the total amount of fertilizer? (currently, 2017, 2020, 2025), (lowest estimate, most probable estimate, highest estimate)

This question was asked in order to gain insight on the use and prospect on the use of liquid fertilizer. Again, the lowest and highest estimates of the respondents showed how certain they were of their estimate.

4: How many hectares of grassland would you estimate a dairy farmer uses on average?

5: How many hectares of grassland would you estimate a contractor with a Smart Fertilizer fertilizes on average annually?

These questions were asked in order to perform a financial analysis which was incorporated in the first setup of the research. However, this analysis was not executed since some of the information that is required for such an analysis varied greatly amongst the respondents, the analysis would therefore be inaccurate.

6: What might be limitations for the use of the fertilizer equipment and how can these limitations be overcome?

This question was asked for both innovations. The question aims for finding out what the limitations of the innovations are and what might be done to overcome these. The answers gain insight on the potential success of the innovations and might provide advice for the producers of the innovations.

7: What are or might become substitutes for the fertilizer equipment and what might become substitutes in general for improving soil fertility?

This question was asked for the current situation and the situation in 2025. The question provides insight on the industry and the competition in this industry for the current and future situation.

8: What are the strengths, weaknesses, opportunities and threats for the fertilizer equipment?

This question was asked for both innovations and the answers to this question provide the input for the SWOT- and TOWS-analysis.

9: Please fill in your estimation of the following investment aspects of the fertilizer equipment at issue

The questions were asked for the innovations and the tradition fertilizer. The sub-questions were asked in order to perform a financial analysis which was incorporated in the first setup of the research. However, this analysis was not executed since some of the information that is required for such an analysis varied greatly amongst the respondents, the analysis would therefore be inaccurate. The answers on these questions did provide insight on how the fertilizers relate to each other in the respondents' perspective, which is useful input for the SWOT- and TOWS-analysis.

10: What is in your opinion the best fertilizer and the best equipment for fertilizing now and in the future?

This question was asked to gain insight on what fertilizer and what fertilizer method is preferred by the respondents currently and for the future. The answers provided the researcher of an insight on how the respondents saw the fertilizer and fertilization industry develop.

11: Business model aspects of producers and users of the fertilizer equipment

The sub-questions of this question addressed all the aspects of a business model of the producers of the fertilizer equipment. Further it gave insight on how the innovations would impact their users.

12: What developments do you expect on the short and on the long term in the Dutch dairy chain?

This question was asked for environment and sustainability in particular, besides that, it was also asked in general for the Dutch dairy chain. The answers on this question are the input for the analysis of the prospect for the Dutch dairy chain and smart fertilization in particular.

13: Do you have any comments, questions or advice on the introduction, this questionnaire or one question in particular?

This question was asked to ensure the respondents have given their comments, and have no questions left for the interviewee.

3.1.2. Interviewing methodology

3.1.2.1. First round

The first round of the Delphi study was held orally by the researcher. Face-to-face meetings were preferred because according to Vogl, dependent on the question, telephone respondents show less

involvement, opinions and suggestions compared to face-to-face interviews (2013). When the respondent was having difficulties with having face-to-face meetings, a telephone interview was conducted instead, this was the case for two respondents. The first round was held orally by means of a semi-structured interview because then the researcher had the ability to interact with the interviewee. Interaction, for example asking for elaboration, can help clarifying the viewpoint of the respondent. In addition to this more aspects might be mentioned for the listings. The downside of interaction, as Barriball and While discuss, is the risk of biased data, and thereby the pressure on the reliability and the validity of the study (1994). However, during the first round the aim of the research was to gain as much aspects as possible, the following round(s) were in place to concretise the interviewees' judgement.

The questionnaire was send beforehand including the introduction of the innovations. This was at the expense of the spontaneity of the respondent. However, the emphasis of the first round lay on the listing of aspects, therefore, sending the questionnaire in advance enhanced the results. The introduction of the innovation had to be send in advance in order to enable the respondent to create a good view on the innovation and form a sound judgement. The interviews have not been tape-recorded in order to comfort the respondent and strengthen the feeling of anonymity. The feeling of comfort and anonymity helped preventing the respondent from giving social desirable answers. The answers of the respondents were written down directly by the researcher.

After all experts were solicited and the questionnaire was prepared, the appointments were made. The introduction of the innovation(s) and the questionnaire were send 3 working-days in advance. The researcher has chosen for this period for two reasons: One, to make sure the respondent has sufficient time to prepare for the interview and two, to ensure the information is still vivid in the mind of the respondent.

The interviews were conducted according to the interview cycle used by Terrier in her research. The interview cycle is displayed below, this cycle aims at maximizing the quality of the output data of the interviews (Terrier, 2007).

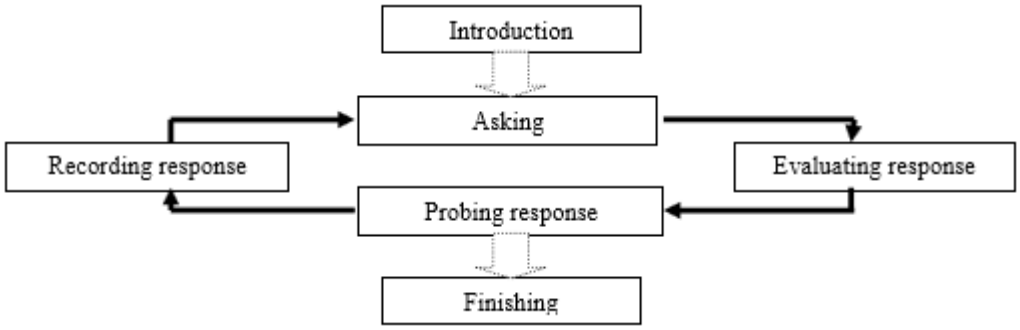

Figure 10: Interview Cycle (Terrier, 2007)

The first step is not part of the cycle, it is the introduction of the researcher and the research and will, logically, only be done at the start of the interview. When the researcher is introduced, the cycle can be started. The first step in the cycle is asking the question. The question is stated in a short and concise manner. When the respondent has stated his/her initial answer, the researcher evaluates the response on completeness, clearness, relevance and validity. If one or more of these criteria do not seem to be fulfilled according to the researchers' judgement, the researcher can probe the response. When the question is fully answered the answer can be recorded and the next question can be asked, the cycle starts over. After the respondent has answered all the questions the interview can be completed by thanking the respondent for his/her participation.

3.1.2.2. Second round

The second round of the Delphi study was conducted by telephone. The results of the first round are incorporated in the questions of the second round. The respondents reacted on the estimations, challenges and potential solutions of which they showed expertise during the first round and/or during their work. This will enhance the depth and quality of the answers that are provided.

After all the interviews of the first round were executed, the results have been summarized and counted. A listing of all the relevant output was made and for each main topic a list of regarding issues is made. Experts have been allocated at the issues of which they have expertise, the judgement for expertise on a certain issue is based on the first round and the profession of the respondent. Each issue was addressed by 1 to 8 respondents, depending on; the amount of times the issue was mentioned, the relevance of the issue for achieving the goal of this study and the number of respondents with expertise on the issue. In two cases an expert was added when the issue required more expertise in order to gain the full scope of it, for instance, when a certain product is mentioned, it will give much more insight when the producer or developer is also interviewed. Adding experts is unusual during a Delphi, but for this research it might be a valuable addition in order to come to a sound future perspective of a certain development. After the list was completed the second round started. During this round the respondent was walked through the interview by addressing one issue at a time. The issues were presented to the respondent as outcome of the first Delphi round. After the issue has been described the respondent was asked after his or her vision on this matter. When the general vision on the issue is written down, specific questions were asked to find out why, how and when these developments will occur. After that, the respondent was asked to describe what the consequences are and who will be influenced by these developments. During these questions the visions of other respondents on the issue have also been given and the respondent was asked what he or she thought of the ideas of their fellow respondents. The interviewer wrote down all the answers directly, when an answer was given in an incoherent fashion, the interviewer first summarized the answer to ensure that the vision of the respondent was in line with what has been written by the interviewer. The interviewing procedure of the second round is graphically shown in the figure below.

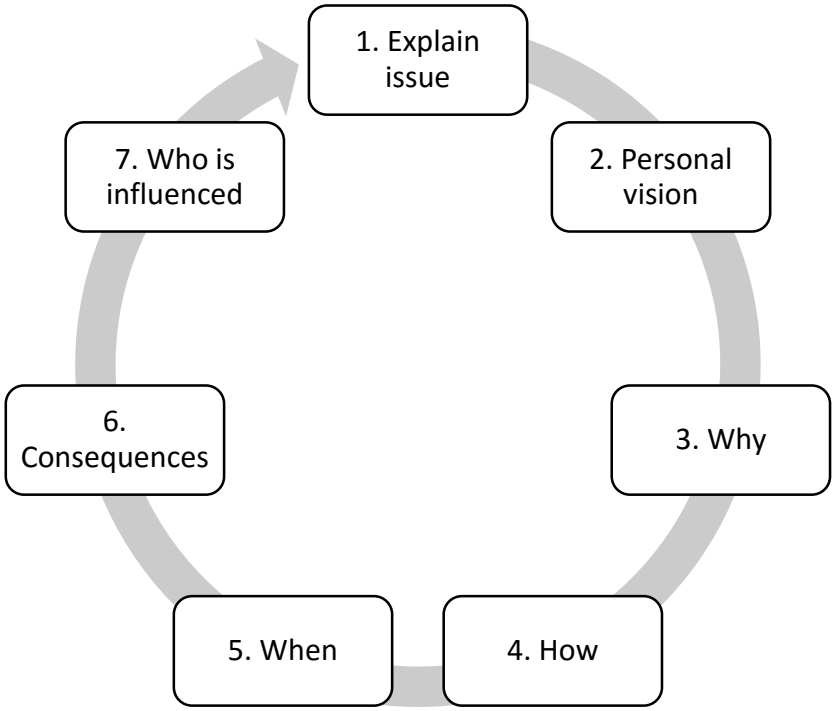

Figure 11: Interviewing procedure round 2

After all issues were covered by the respondent, the interviewer thanked the respondent for his or her cooperation and explained what will happen during the remainder of this research. In order to prevent misinterpretations, the respondents were asked if they were okay with being called again in case anything was unclear during the processing of the results. These calls for further elaboration have been made 6 times and thereby form the third round.

3.2. Methods of data-analysis

This section describes the methods that have been used in order to analyse all the data that was gathered by the Delphi-study. The Business Model Canvas, Porter's five competitive forces, SWOT-analysis, and the TOWS-matrix are discussed specifically.

3.2.1. Business Model Canvas

Specific research question 2 aims at describing the business model of the spoked-wheel fertilizer and the disc-injection fertilizer and their impact on the business model of Dutch dairy farms and the existing business models active in the fertilizer industry and fertilization industry operating in the Netherlands. In order to analyse and provide a full description of the business models the Business Model Canvas (BMC) will be used. To analyse which business models might be affected by the innovations at issue the BMC will be used to see what actors are involved with the businesses of the innovations.

The BMC is a visual representation of a complete business model. It consists of 9 building blocks that are all relevant for the business model, the BMC format is displayed below (Osterwalder & Pigneur, 2010).

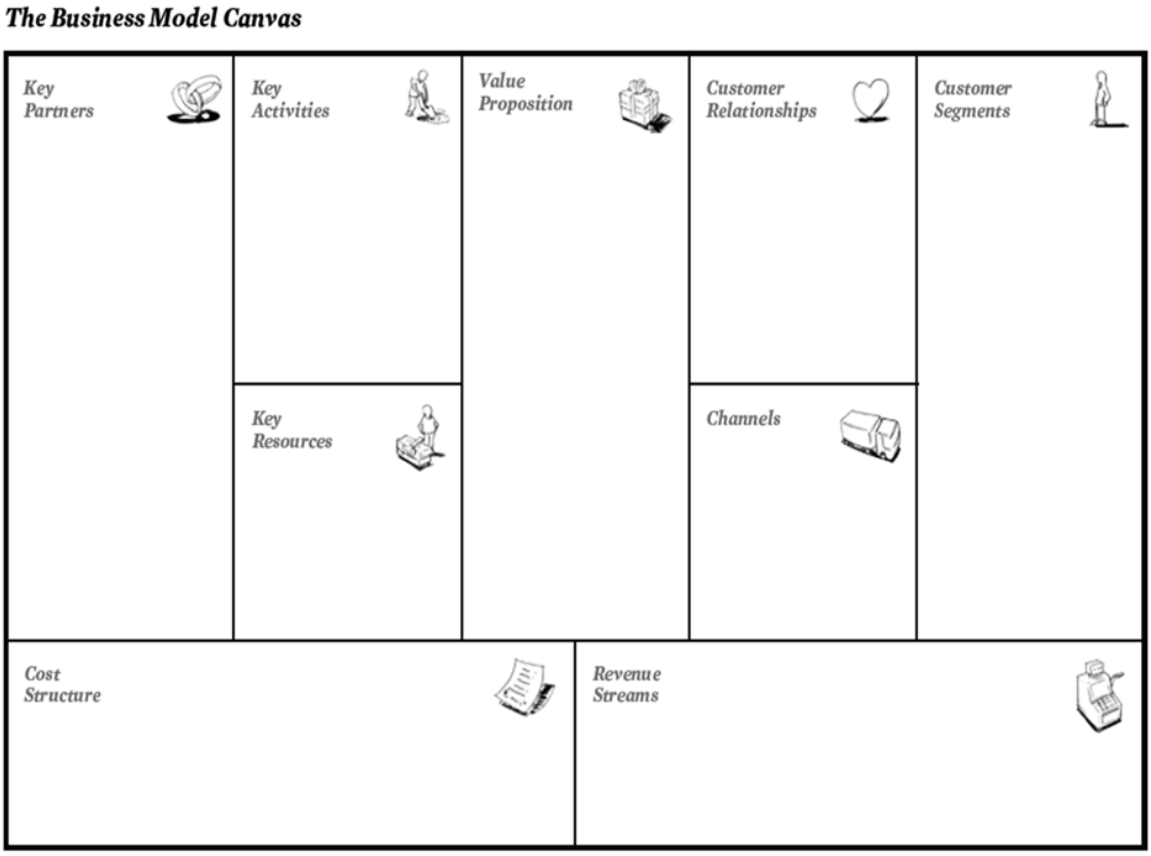

Figure 12: Business Model Canvas (Osterwalder & Pigneur, 2010)

The Key Partners block describes the major partners that are needed to run the business that is being analysed. According to Osterwalder and Pigneur there are 4 types of partnerships; strategic alliances between non-competitors, co-opetition (strategic partnership between competitors), joint ventures and buyer-supplier relationships. The Key Activities describe the activities that are essential for the business at issue, it tells what has to be done in order to keep the business model running. The Key Resources consist of the resources that are needed in order to perform the Key Activities, for example people, fuel, utilities, machinery etcetera. The Value Proposition block describes how exactly the business creates value that is delivered to the customers. This block answers the question what needs of the customers are satisfied by the business' products and services. The Customer Relationships describes what kind of relations the business at issue has or should have with its customers. In the Customer Segments is described who the customers are and how they can be characterized. The Channels block is in place to describe how the customer segments are reached before, while and after the purchase. At the Cost Structure the major costs for resources and activities are described. Also the type of business, cost-driven or value-driven, comes forth in this block. The last block, Revenue Streams, shows how turnover is created. It answers the question what is sold or delivered, and how do customers pay for this? The relative weight of each revenue stream can also be indicated in this block (Osterwalder & Pigneur, 2010).

The BMC will be used to see what business models might be changed by the innovations that are being researched. The BMC enables the researcher to quickly see what part of the business changes and what consequences this has for the entire business model.

3.2.2. Porter's five competitive forces

The industry to which the spoked-wheel fertilizer and the disc-injection fertilizer belong has to be studied and described in order to assess the potential for success of these innovations. The industry analysis will be done by Porter's five competitive forces. This model aims at providing insight in the competitive climate of a certain industry (Porter, 1979). A practical manner of application of this model has been developed by Grundy in his study (2006). On the basis of Porter's model with the practicalities provided by Grundy the competitive climate of the innovations will be assessed.

The five forces that are governing competition in a specific industry are shown in Figure 13 below. Each of these forces influence the profitability in the industry and the strongest forces are the ones that determine how the company at issue should act in the future. In other words, the strongest forces determine strategy.

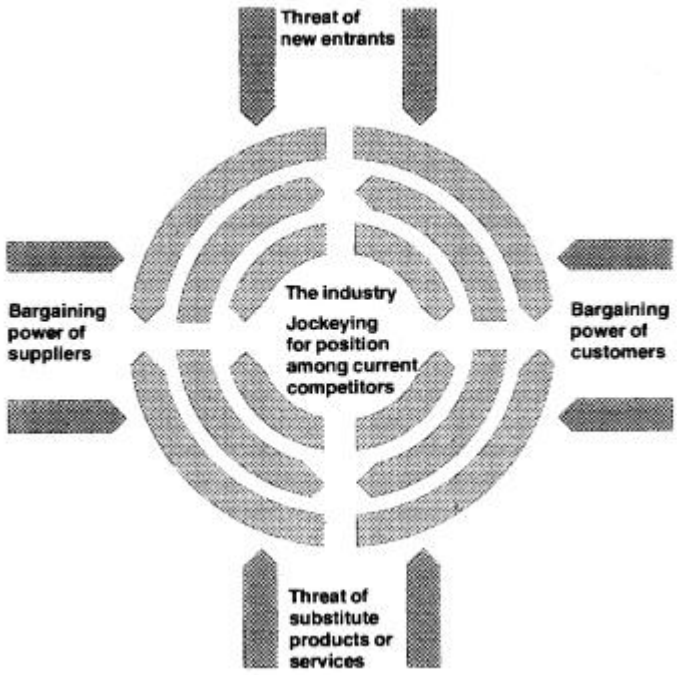

Figure 13 Porter's five competitive forces (Porter, 1979)

3.2.2.1. Threat of new entrants

When new entrants come to an industry they aim for a share in that market, a share that might be gained at the expense of the company at issue. According to Porter the seriousness of the threat depends on two factors; the barriers to entry and the reaction from existing competitors towards newcomers. Porter identifies six major sources of barriers to entry (1979):

- Economies of scale
- Product differentiation
- Capital requirements
- Cost disadvantages (independent of size)
- Access to distribution channels
- Government policy

In addition to these barriers the potential reaction of competitors who already are in the industry can also withhold possible new entrants from actually doing so.

3.2.2.2. Bargaining power of suppliers

When suppliers have a strong bargaining position they can use this to demand high prices or to reduce quality without losing turnover. According to Porter a supplier group is powerful in the following cases (1979):

- Only a few companies are selling this kind of product
- The buyers of this product are with larger numbers
- The product that is sold has a high degree of uniqueness
- Switching costs; switching to another supplier directly brings costs for the buyer
- The supplier does not have to contend with other products that are sold to the industry
- The supplier forms a forward integrating-threat to the industry it sells to
- The industry is not an important customer of the supplier

3.2.2.3. Bargaining power of customers

If customers possess a strong bargaining position they are able to do the opposite from suppliers with a strong bargaining position. They 'can force down prices, demand higher quality or more service, and play competitors off against each other' (Porter, 1979). Porter states that customers have a strong bargaining position when (1979):

- The customers can buy large volumes
- Only a few customers buy the industry's product
- The products purchased are standard
- The products purchased are a significant part of the total costs of the customers
- The customers generate low profits with the industry's product
- The product is unimportant for the quality of the customers' product/service
- The product does not save the customer money
- The customer forms a backward integrating-threat to the industry it buys from

3.2.2.4. Threat of substitute products or services

Substitutes for the product or service of the industry are another source of threat for the industry. The industry's potential can get limited by substitutes, Porter states the following: "Unless it can upgrade the quality of the product or differentiate it somehow, the industry will suffer in earnings and possibly in growth" (1979). An important aspect of the success of the industry's product in comparison is the price-performance trade-off; the better the trade-off the less threat the substitute forms. When substitutes are produced by companies with high profits the threat enlarges (Porter, 1979).

3.2.2.5. Jockeying for position

Existing competitors within the industry of the company at issue of course are also a competitive force. The following factors determine the intensity of the rivalry in the industry (Porter, 1979):

- Competitors are numerous
- Competitors are (roughly) equal in size and power
- The industry grows slowly
- The products within the industry are indifferent
- Switching costs (for customers) are low
- Fixed costs are high
- Perishable products
- Customers buy in large batches at once
- The exit barriers of the industry are high

- The rivals of the company at issue are very diverse

3.2.2.6. Vector format

A critique of Grundy at Porter's five forces model is that it does not include the relative importance of each industry specific aspect. Grundy suggests the use of a vector format, which stems from the force-field analysis (Grundy, 2006). The vector format can provide a quick overview of the attractiveness of an industry by picturing negative and positive aspects opposed from each other. In addition to that the length of each arrow indicates the weight of the regarding aspect. Of course, this relative weight is the perception of the researcher or the research subjects. The vector format below about funerals case is an example from Grundy's study.

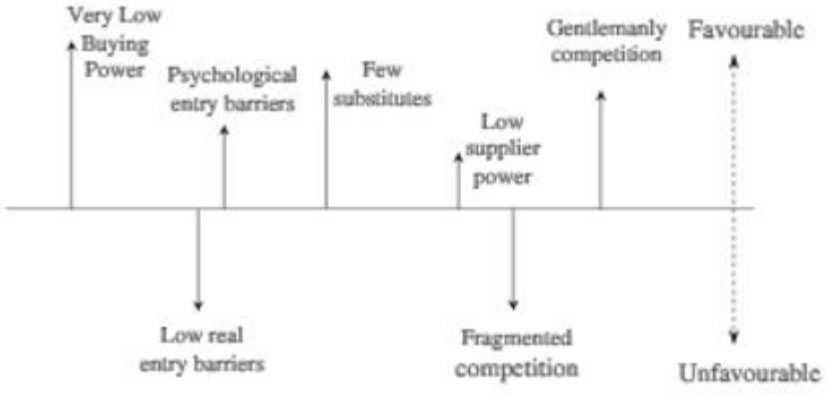

Figure 14: Vector format funerals case (Grundy, 2006)

Another thing to bear in mind when analysing the five forces is that they are interdependent from each other. Grundy has stated the following 'key internal interdependencies' in his study (Grundy, 2006):

- Customers might encourage new entrants: this reduces the entry barriers
- Customers may actively search for substitutes: this encourages producers of substitutes
- New entrants may think of backward integration: this strengthens their position in the industry
- Suppliers could integrate forward: the could sell substitutes of the industry's product

These 4 key interdependencies have to be taken into account when the risk of competition is being assessed.

3.2.3. Challenges and potential solutions

For the analysis of the challenges and potential solutions that were described and reflected on by the respondents, no specific analysis method is used. For each development that respondents had to reflect upon the following questions have been asked:

- What is your personal vision on this challenge/potential solution?
- Why will this development occur?
- How will this development occur?
- When will this development occur?
- What are the consequences of this development?
- Who/what companies are influenced by this development?

The answers on these questions were analysed by comparing the answers of all respondents per development, and thereby determine what can be expected and what is still uncertain for the specific development. When one of the respondents proved to possess the most expertise on a

certain development, the opinion of this respondent has been given more weight over the other opinions. This judgment was made based on literature, the profession of the respondent, the background of the respondent, and the expertise that was shown by the respondent on the specific subject. The analysis of these answers aimed to provide the results that enable the researcher to answer specific research question 3 and the regarding sub-questions.

3.2.4. SWOT

SWOT is an analysis tool that has its focus on both the internal aspects and the external aspects. The internal aspects are in this case the strong and weak points of the regarding innovation. The external aspects are found in opportunities and threats for this innovation. For each category the aspects will be listed and prioritized on importance (Dyson, 2004).

A SWOT analysis bears several risks when it is applied. The first risk is that long lists for each category are produced, but it remains unclear which factors are really important. Therefore, when a SWOT analysis is executed, prioritization of the issues is required. This prioritization is done in two steps, the first step is to only include the most relevant factors in the analysis. The second step is to give weight to the factors; for strengths and weaknesses this weight indicates the importance of the factors, for opportunities and threats it indicates the likeliness that these developments will occur. Another risk of SWOT is a lack of specificity, where issues that are identified are very general and do not explain the underlying reasons. Finally, if the analysis is not thoroughly executed the results will be generated from preconceived, biased views. This can be prevented by using other analysis methods (for this research the Delphi-method) for the gathering of input for the SWOT analysis (Johnson, et al., 2012).

When all factors are listed and prioritized, a further analysis is of use. The TOWS matrix is a tool that builds directly on the SWOT output. This matrix enables the researcher to analyse how the internal factors interact with the external factors. To gain insight on how the environment (the external aspects) relates to the strengths and weaknesses a scoring mechanism can be used. Experts can score whether a strength of the product has a positive or negative influence on the opportunity or threat, the same applies for weaknesses. For example, due to an opportunity a weakness of the product becomes less relevant, this relation would be positive. To indicate the strength of these positive or negative relationships an additional score can be added, for instance, the previously mentioned relationship between the weakness and the opportunity is +3 on a scale from -5 to +5. In the figure below a format for a TOWS matrix is given. The SO square shows how good the strengths exploit the opportunities, the ST square shows what strengths can help avoid the determined threats. The WO square shows the effect of the weaknesses on the opportunities in the environment. The WT square shows what weaknesses interact with the threats, these weaknesses can become very large because of the negative interaction with the threats (Johnson, et al., 2012) (Weihrich, 1982).

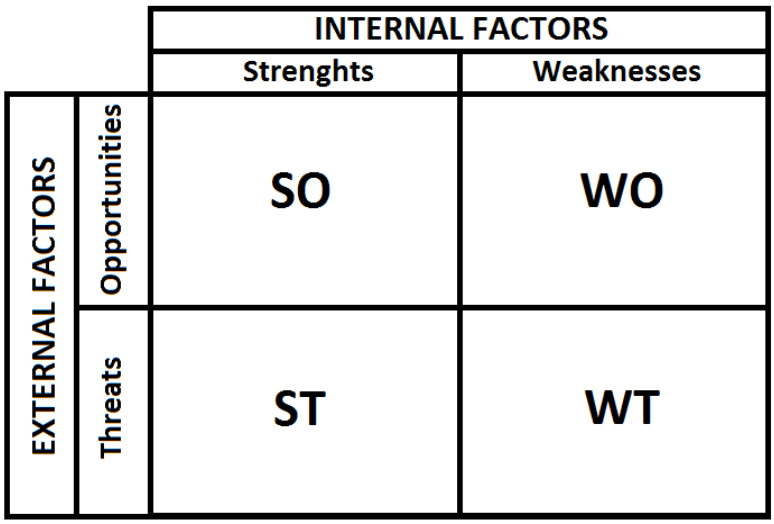

Figure 15: TOWS matrix

3.3. Summary of methodology

The data-collection was done by the means of a Delphi-study. 32 respondents have been interviewed during the two rounds of the Delphi-study. In the first round the respondents were interviewed face-to-face in order to list as much relevant aspects as possible. The interviews of the first round were held according to the interview-cycle. During the second round the respondents reacted and shared their vision on challenges and potential solutions that were described by respondents during the first round. The second round was conducted by telephone.

The business model of the spoked-wheel fertilizer and the disc-injection fertilizer has been analysed by means of the Business Model Canvas. In addition to that the potential impact on the business model of Dutch dairy farms and the existing business models active in the fertilizer industry and fertilization industry operating in the Netherlands was analysed.

The industry to which the spoked-wheel fertilizer and the disc-injection fertilizer belong is analysed by means of Porter's five competitive forces model, with the practical application of Grundy's vector format in order to place the forces in perspective.

The challenges and potential solutions that are subject of this research each have been addressed by 1 to 8 respondents, depending on; the amount of times the development was mentioned, the relevance of the development for achieving the goal of this study and the number of respondents with expertise on the development.

SWOT-analysis is used to assess the potential for success of the innovations that are subject of this research. The strengths, weaknesses, opportunities and threats will be listed and prioritized based on the input of the respondents and the literature. After this, a TOWS-matrix was executed with the SWOT results as input in order to see how the internal factors react with the external factors.

4. Results

In this chapter the results of the empirical part, the Delphi study, are presented and analysed in order to answer the research questions stated in the introduction of this report. Firstly, the business model of fertilizer injector producers is described. Secondly, the industry in which these fertilizer injectors producers operate is analysed by means of Porter's five competitive forces and and the vector format of Grundy. Then the challenges and potential solutions are described. Finally, the SWOT-analysis and TOWS-matrix on the two innovations are provided. The summarized results of the second round can be found in 'Annex 6 Results 2nd Round'.

4.1. Business models of fertilizer injector producer

First the Business Model Canvas for the producers of the spoked-wheel fertilizer and disc-injection fertilizer will be provided. These business models are presented in one and the same BMC since the output of the Delphi study was equal for both innovations. By the means of this BMC it becomes clear how the companies that produce the liquid fertilizer injectors look like and what companies are influenced by the sales of these liquid fertilizer injectors. After that, the companies that are in the BMC and are active in the Dutch dairy chain will be further analysed on how the business models of these companies will change and whether their change influences other companies in the Dutch dairy chain. The BMC is displayed in Figure 16 below:

Figure 16: Business Model Canvas of the liquid fertilizer injectors at issue (see Annex 7 for spreadsheet version)

4.1.1.1. Key Partners operating in the Dutch dairy chain

The first key partner that is mentioned is the liquid fertilizer supplier, this supplier is benefitted with an increase of sale of the innovations and vice versa, therefore they are very well suited to be partners. The BMC of the liquid fertilizer supplier changes on the following aspects; the key partners and channels. For the key partners this is logically the adding of the liquid fertilizer injector producer. For the channels the change concerns the adding of a marketing channel; via the seller of the liquid fertilizer injector. The same applies for the liquid fertilizer producers, and then especially the producers of waste-streams that can be used as liquid fertilizer. For instance pig farmers who deliver their waste-stream to the intermediary. Such liquid fertilizer producers also use the injector producer as a marketing channel. Feed suppliers of dairy farmers are also a key partner for the producer of the innovations as they consult dairy farmers in their choices. The business model of the feed suppliers does not change, unless they are also the fertilizer suppliers (which is not uncommon in the Dutch dairy sector). Consultants of contractors, independent information agencies, research and media are all key partners because they can influence sales with publications or advice in favour of the innovations, the business models of these partners does not change. Manure processors can be a key partner by advising the dairy farmers to inject the processed manure with the innovations, the other way around is also applicable; the more liquid fertilizer injectors are out there, the more manure will be processed.

4.1.1.2. Customer segments operating in the Dutch dairy chain

The first customer segment in the Dutch dairy chain is the segment of contractors. The business model of contractors that purchase a liquid fertilizer injector will change on several aspects. Firstly the injector seller will be added to the list of key partners for service, repairs, maintenance, consultancy, calibration, parts and start-up. The value proposition of the contractor towards the dairy farmer also changes, since he can now offer the same value proposition for fertilizing as the value proposition of the injector seller. Injecting fertilizer can be added to the key activities of the contractor. Liquid fertilizer and/or waste-streams can be added to the key resources of the contractor. The cost structure will be influenced by the investment in the machine, the investment in logistics of the fertilizer, maintenance and the purchase of liquid fertilizer. An extra revenue stream is added with liquid fertilizer injection.

Another customer segment are individual dairy farmers or a group of dairy farmers who share the liquid fertilizer injector. This segment is not considered to be very large. The dairy farmers' business model changes as follows: for key resources liquid fertilizer and/or waste-streams as fertilizer are added. For key partners the seller of the injector might be added, if it was not a key partner yet (for other machines). The value proposition of the dairy farmer can be extended with the fact that the fertilization is done with an eye for the environment. The cost structure of dairy farms changes for the same aspects as the cost structure of the contractors and in addition to that less costs are made for additional feed. The revenue streams might be higher in case more feed is sold due to a surplus. Because the value proposition of milk is changed when dairy farmers use liquid fertilizer injection, the value proposition of dairy processors and retailers is also slightly changed. At this moment this is not communicated, but when CO2-footprints become a more important criteria this very well might be the case.

Traders are also a customer segment active in the Dutch dairy chain, this segment exists out of dealers, machinery traders, and mechanization companies. The business models of these companies change at multiple points. The value proposition, cost structure and revenue stream block are extended with the sale or purchase of the liquid fertilizer injectors. The producer of the injector is added to the key partners block. The liquid fertilizer injector is added to the key resources block.

4.1.1.3. Other companies influenced by the sale of liquid fertilizer injectors

The suppliers of the key resources for the producer of the liquid fertilizer injector benefit by an increased revenue stream in case the liquid fertilizer injectors are sold. From the marketing channels the research institutes benefit of the work they are commissioned to do in order to find the effects of injecting liquid fertilizer with these machines and to further develop the machines.

4.2. Industry analysis

4.2.1. Risk of competition

The industry of fertilizer machines will be analysed by means of Porters five competitive forces. At the end of this section the results of this analysis will be graphically displayed by Grundy's vector format.

4.2.1.1. Threat of new entrants

The highest entry barrier appears to be the capital requirements, as respondents state that the development-costs of a fertilizer machine are very high and have to be made before being able to enter the industry. Other entry barriers are the access to distribution channels and for the future might be government policy. The distribution channels, machinery dealers, have to be convinced of the machine's potential before becoming a dealer, as soon as the machine starts to be a success this will be easy, but the first dealers are hard to come by according to some respondents. Positive publications and research results can help convincing dealers and potential buyers of the use of the machine at issue. Government policy might restrict methods of application and thereby will complicate the entrance of new machines and companies.

The reaction of businesses currently involved in the industry is a large entry barrier in the fertilizer machine industry. This barrier is not created by direct competitors, but by the granulate fertilizer producers. As new methods often include liquid fertilizer, the granulate fertilizer producers see a threat for their current market share. As discussed earlier in this chapter the granulate fertilizer producers and suppliers have a strong lobby in favour of their product and against liquid fertilizer.

4.2.1.2. Bargaining power of suppliers

Suppliers of the fertilizer machine industry, or the agricultural machine industry in general do not have a very large bargaining power since the materials that are used can be made by a lot of companies. The sensors and software for the machines are an exception according to some respondents, since not many companies can produce these, they have a strong bargaining position.

4.2.1.3. Bargaining power of customers

The bargaining power of customers is not very high nor very low. The bargaining power is influenced upwards by the fact that the purchased product is a significant part of the total costs of the customers, especially for contractors and arable farmers. However, the bargaining power is influenced downwards by the fact that a lot of customers buy the industry's product and the product is rather important for the end-product of arable farmers and the service of the contractors.

4.2.1.4. *Threat of substitute products or services*

Substitutes are an increasing threat in the fertilizer machine industry because of the decreasing price-performance trade-off. For example the granulate spreader has a very attractive price, but its performance is being outdone more and more. Due to rapid developments in the application methods the threat of substitute products also increases. A good example of this is the high pressure injection, currently only used in arable farming and on sports fields but being developed for appliance on agricultural grassland.

4.2.1.5. *Jockeying for position*

At this moment the companies that deal in granulate spreaders have a very strong position in the industry because of their good price-performance trade-off and because of the strong lobby of the granulate fertilizer producers. As stated above, the price-performance trade-off is weakening because of better performances of other products. However, respondents state that the lobby is more active than ever, in order to prevent liquid fertilizer from taking in a larger share of the market.

4.2.1.6. *Vector format*

The vector format is designed from the perspective of the liquid fertilizer injectors as these are the subject of this research. All the vectors larger than 0 represent a positive effect for the liquid fertilizer injectors at issue. The negative vectors have a negative effect, meaning they form a threat in the industry of the liquid fertilizer injectors. The vector format is shown below in Figure 17.

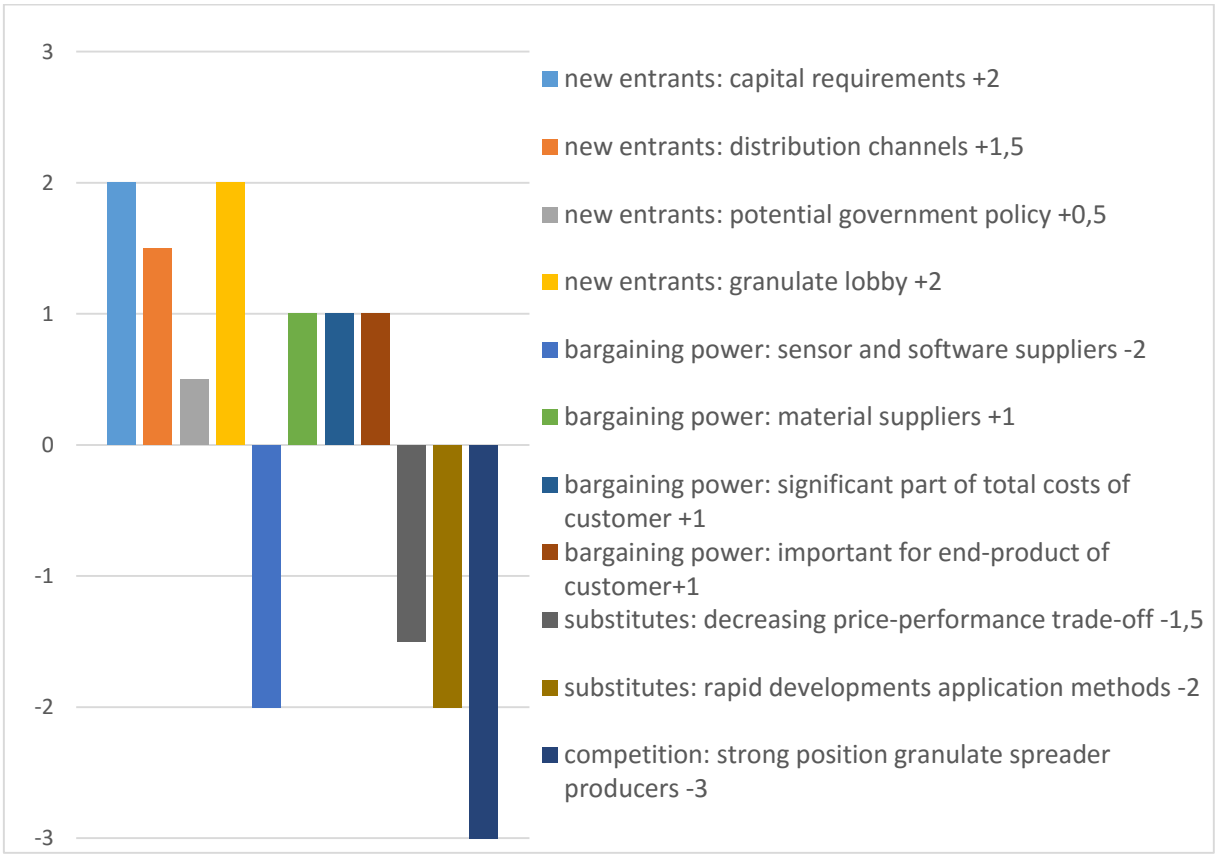

Figure 17: Vector format from perspective of liquid fertilizer injector producer

The liquid fertilizer injectors at issue are already developed and therefore the high capital requirements for new entrants are favourable, since they already have fulfilled these

requirements. The rapid developments of substitutes form large threat for the liquid fertilizer producers since the substitutes will most likely outperform them, resulting in a better price-performance trade-off for the substitutes in comparison with the spoked-wheel fertilizer and the disc-injection fertilizer. The strong position of the granulate spreader producers is the largest threat for the spoked-wheel fertilizer and disc-injection fertilizer because the granulate spreader producers are backed by the strong granulate lobby.

4.3. Challenges and potential solutions

The challenges for the Dutch dairy farmers and the potential solutions that might enable them to deal with these challenges that are analysed in this section were all mentioned during the first Delphi round, during the second round the challenges and solutions were given to a certain group of respondents in order to let them give their vision on these. After that the respondents are asked a couple of questions in order to get more in-depth information on why, how, when, what the consequences are and who will be influenced by the challenges and solutions. The challenges and their impact on the dairy farms, contractors, fertilizer suppliers and –producers will be described and analysed first. Thereafter the potential solutions and their impact are analysed.

4.3.1. Challenges

4.3.1.1. Phosphate rights

Respondents 3E, 3B, 1C, 4F, and 4J answered questions on this restriction for dairy farms.

The advantages of phosphate rights is that dairy farmers are now strongly stimulated to be as efficient as possible with phosphate, this will result in all-round increase in mineral efficiency which is beneficial for the environment as well as for the dairy farmers because then they can keep more cows with the same phosphate rights. Respondent 4J states some methods for steering the phosphate efficiency on the dairy farms:

4J:"Dairy farmers can steer to stay under the phosphate-ceiling by for example; reduce the amount of young stock they keep, and feed less phosphorus, so less phosphate is produced on the farm."

The largest disadvantage is that the market is (again) restrained and growth is limited. Dairy farmers have to do a larger investment in case they want to expand. The cycle indicator will be an increasingly important tool for dairy farmers and their consultants to make the cycle as efficient as possible. More dairy farmers without a successor will quit while the phosphate rights can form an extra source of money for retirement. Prices for land will stabilise instead of rising further because of the decrease in growth of dairy farms the phosphate rights will cause. A new trade flow will emerge for the phosphate rights. The effect of the introduction of phosphate rights on grazing is something the respondents could not agree on; two of the five respondents think less cows will be grazing because of the negative effect on the mineral-cycle, two other respondents oppose this because the grazing of cows is an image matter and any decrease will be prevented. 1C sees this as follows:

1C: "Grazing is a matter of image, this will always have the overtone over efficiency. The goal of 80 percent grazing is set, and the sector has to beware this is not going to be a restriction set by the government. A exception might be made in the cycle-indicator for the missed mineral-efficiency due to grazing, so that it is not a motive to keep the cows inside."

4J does not agree with the fact that grazing has a negative influence on the phosphate production because the phosphate production is not much higher during grazing, and the additional feed that

is bought in case of grazing often holds less phosphate because less protein is required compared to not-grazing systems. The mineral-cycle might be negatively influenced, but there is also a positive effect for grazing; since growth is limited more farms will remain able to graze the cows.

The impact on the chain of phosphate rights will be immense, where a lot of growth of dairy farms was expected it now is limited again. This means that all suppliers of dairy farms will have less sales then predicted, such as feed suppliers, machinery suppliers, fertilizer suppliers, fertilizer producers, construction companies, consultancies, contractors, breeding companies, utilities and so on. The dairy processors will have less milk than expected and thereby make less sales as well, the cost price of milk will be higher because the supply does not grow as much as expected. The retailers therefore will also have to pay a higher price for the dairy products they order.

4.3.1.2. Manure legislation might be sharpened

Respondents 1G, 2B, 1I, 1A, 4E, and 3C answered questions on this potential challenge.

The respondents have different visions on whether the manure legislation will be changed and how it will change if this is the case. 2B expects that a change in permitted application methods will occur; this change would imply that the manure has to be applied in combination with water in order to get the emission down and the mineral efficiency up. Where 2B and 3C think this will be obligatory, 1I expects this method to be added to the currently permitted manure application methods. Whether the use limits for nitrogen and phosphate will be sharpened depends on nitrates directives being met or not. Respondent 1A expects that these directives will not be met and therefore the use limits will be sharpened. 1G opposes this because the directives are almost met. Two other respondents, 1I and 3C, expect the use limits will not be sharpened because the phosphate rights will control the use of minerals enough. If manure legislation is sharpened or changed it is expected to happen in 2020 with the start of the reformed Common Agricultural Policy (CAP) by 1G, 2B, 1I, 1A, and 3C. 4E however states that the next nitrate action program already activates in 2018, and that changes will be introduced in this action program.

1A and 4E expect the legislation to become more company-specific. Where 1A expects that the use limits will vary based on soil-type, 4E expects use limits based on the performance on mineral efficiency of each dairy farm:

4E: "There will be more differentiation between dairy farms, those who perform well with regards to mineral efficiency will be allowed to use more manure and fertilizer, and the underperformers will have to deal with sharper use limits."

The vision of 4E thereby also accounts for soil-type, as the dairy farmers are rewarded or restricted based on how well they cope with the soil-type on their farm.

If the use limits are sharpened a decrease in feed production per hectare is expected, which will result in less cows being held on the same amount of hectares, complicating growth of dairy farms even more, which has a negative effect for the whole Dutch dairy chain. If use limits are linked to performance on mineral efficiency of individual dairy farms, it will stimulate dairy farmers to improve this efficiency even more, resulting in lower nitrate levels in the groundwater, and it will create more employment for consultancies in order to help dairy farmers gain mineral efficiency. This increased focus on mineral efficiency will also boost sales of suppliers that can deliver efficiency increasing methods or machines. As for all developments that are beneficial for the environment the whole Dutch dairy chain benefits from a better image of dairy farmers because it increases the sales of dairy products.

Box 3: Crop yield per hectare will decline due to the manure legislation

Respondents 1B, 1E, and 1A answered questions on this challenge. 1A states that *"the current legislation is more than sufficient for maintaining crop yield".* 1B however thinks this decline in crop yield has already started and will worsen when legislation would be sharpened in the future. 1E and 1B agree that it is hard to measure if the legislation is the cause of a decline in yield per hectare because it is dependent on so many variables. 1E is therefore not sure whether it is currently the case, but expects it to become so when manure legislation is sharpened. All three respondents agree that increasing the mineral efficiency is the way for dealing with sharp manure legislation.

4.3.1.3. A low CO_2 (-equivalent) footprint per kilogram milk will be rewarded

Respondents 1G, 1C, 4G, 4J, and 4I answered questions on this challenge.

4G, 4J, and 4I expect the dairy processors to reward dairy farmers who realize a low footprint of CO_2 per kilogram milk. However, 4G states that if this reward does not stimulate CO_2 reduction enough, the government will intervene with restrictions. 1G and 1C expect that the government

will not wait for this and will set restrictions much sooner. 1G expects a CO_2 tax where dairy farmers pay a tax for the level of CO_2 they produce on their farm. 1C is not certain whether the government will reward low or punish high CO_2 production, but thinks a CO_2 –ceiling will be set by the government. 4G is certain:

4G: "A lot of research is currently done after how to influence CO_2-equivalents on the dairy farms. The methane-production of cows plays a major role in this. One way or another within a matter of a few years the dairy farmer is stimulated or forced to reduce CO_2 –production!"

The CO_2 production might be measured by a system-analysis of the dairy farm, counting points for every CO_2 reducing method that is applied. Another suggestion was the use of the mineral-cycle-indicator since losses become evident in this tool. Currently the mineral cycle-indicator gives a general estimate, however, this tool is being developed into a more accurate version for CO_2 footprints. Another suggestion was that in the future the dairy processors could analyse the CO_2 footprint from the contents of the milk.

Whether the CO_2 reduction is rewarded or not enough CO_2 reduction is punished, the consequences are the same. Dairy farmers will pursue a lower CO_2 production per kilogram of milk because they benefit from it either way. Of course the environment also benefits from a lower CO_2 footprint from the dairy sector. In case of a CO_2 –ceiling the dairy farmers will lower the production of CO_2 to this ceiling, but not any further.

The whole Dutch dairy chain will benefit of a better image of dairy. In case of a rewarding-system the dairy farmers could benefit from the reward, however, the dairy farmers will have to invest in CO_2 reducing methods first which will increase their cost structure. Dairy processors and retailers benefit from an extra marketing tool and have a Unique Selling Point on the world- and domestic market. The suppliers and developers of CO_2 reducing methods will benefit greatly if dairy farmers are inclined to reduce their CO_2 production because their market will grow. Consultancies with know-how on CO_2 reduction will also have more employment since the dairy farmers will demand more consultancy on this subject.

Box 5: Methods for emission reduction

Respondent 1G states that recent research has shown that by adding Lactobacillus spp. to manure, the ammonia-emission of stored manure can be reduced by 54 to 66 percent. Another advantage of adding this bacteria is that the treated manure is better utilized when it is used in a biogas installation in comparison with untreated manure. The costs of this CO_2 reduction method are still relatively high when one tries to reduce the ammonia-emission of stored manure with more than 50 percent. However, 1G expects that within 2 to 3 years this method will be in practice, as long as there is enough funding for the research that has to be done before application in practice is possible.

Another method for reducing the emission of CO_2 –equivalents is via feed-additions. According to respondent 4A a powder is developed by biochemical company DSM in order to reduce the CO_2 –equivalent emission of cows, especially the methane emission since this is the major source of greenhouse gas-emissions by cows. 4A states that the powder is functioning in the laboratory of DSM, but that it has not been proven in practice.

4.3.1.4. Compulsory reduction of greenhouse gas emissions

Respondents 4J, 1D, 4I, 1C, and 3A answered questions on this potential restriction.

All respondents expect restrictions on the amount of greenhouse gasses that are produced by a dairy farm. 4J and 4I expect a greenhouse gas ceiling just like the phosphate ceiling. 1C and 3A

expect the mineral cycle indicator to be adapted so that the greenhouse gasses are also accounted for in one system. 1D and 4I expect the restrictions from the Dutch government, whereas 4J, 1C and 3A expect the European Union to enforce these restrictions. 4J expects that the Dutch dairy chain itself will also come with restrictions, when rewarding low emission alone is not enough. According to 1C and 3A the mineral cycle indicator will become obligatory for all dairy farmers from the first of January 2016, then a part of the emissions are already accounted for, the adaptions in order to restrict more on greenhouse gasses can be implemented in the following years. 4I does not expect greenhouse gas restrictions on the short term unless new treaties are agreed upon in the European Union.

A lot of the consequences are the same as in the previous section; where rewarding CO_2 –reduction was the topic. However, in the case of compulsory reduction the dairy farmers must do investments. According to 4I this could cause the reduction of greenhouse gasses to come into an acceleration:

4I: "Innovations that in an earlier stage were too expensive in case of voluntary reduction will now be purchased causing the reduction of greenhouse gas emissions to accelerate."

1C and 3A state that in case of a greenhouse gas-ceiling per farm it would stimulate the reduction, because more reduction would grant farms to hold more cows. 4J expects that this will not occur because the dairy farmers will not reduce the emissions any further when the ceiling is reached.

Dairy farmers would suffer from these restrictions because they are obliged to invest, and are even more limited in growth. Extensive dairy farmers are even more disadvantaged since they feed more carbon to their cows, which increases the emissions of greenhouse gasses. Small-scale dairy farms might become troubled because the required investments are too costly. The Dutch dairy chain in general will benefit when the milk is produced with less pressure on the environment. Especially the dairy processors and retailers will benefit when the restrictions are imposed by them. Suppliers, developers and consultants active in the CO_2 –emission reduction will benefit from a growing market.

4.3.1.5. Grazing

Respondents 3B, 1J, 4F, 4I, and 4E answered questions on how this will develop.

The respondents did not agree at all on how the percentage of cows grazing will develop in the Dutch dairy sector. 3B expects it to remain at the current level of approximately 70 percent, whereas 4I thinks the cows will determine how much is ideal for them. 1J expects the percentage of cows grazing to increase to 80 percent because that is the goal the sector has set for itself. When the 80 percent is not reached by the sector itself, 1J expects the government to intervene. 4F thinks along the same line, but is convinced all the cows will graze in The Netherlands:

4F: "Over 10 years the grazing percentage is 100 percent because grazing will become obligatory if the dairy processors cannot get this percentage high enough by rewarding for grazing!"

4E opposes to the intervening of the government regarding grazing, expecting the sector to take care of it. All respondents agree that in the dairy processors will influence the percentage by paying a premium per kilogram milk, as they currently are doing already. 3B expects an additional premium per kilogram milk from the government. 4I states that the study evenings of young farmers also positively influence the grazing percentage. The disadvantages of grazing are a reduction of grass yield, a limitation for expansion, it is less labour efficient because the grassland management is rather complicated. The effects on emission are diverse; the mineral efficiency is lower because the manure and urine are not efficiently placed, but the ammonia emission is lower

due to the fact manure and urine do not come into contact with each other. 4E expects that the end-balance of emissions by grazing will be the same as for housing the cows throughout the year.

4.3.1.6. Use of preventive antibiotics is reduced

Respondents 1D, 4A, and 4I answered questions on this restriction.

4A expects an actual banning of preventive antibiotics, whereas 1D and 4I expect a reduction of the maximum allowed dosing per animal per day. 4I does not expect a banning of preventive antibiotics since the sector will take care of this on its own and because more alternative medicines are available. A large consequence of a banning or further restriction of preventive antibiotics will be the increased usage of alternative medicines. 1D expects that healthier feed will be more used. It is likely that the percentage of culled cows will increase because the cows with a high somatic cell count will be culled sooner. Cows will increasingly be monitored individually to recognize problems in an early stage.

4I: "Cows will be monitored better and more individually, so that the farmer is faster and better informed on the animal health and actions can be undertaken sooner so antibiotics are not always necessary."

1D expects a further reduction of the maximum allowed dosing per animal per day within the next five years. 4A expects that preventive antibiotics become banned in five to ten years from now, after the dairy farmers are used to the recent restrictions they have to cope with.

The impact on the Dutch dairy chain of a banning or further restriction of preventive antibiotics will be beneficial for the producers and sellers of alternative medicines since their market will expand. The pharmaceutical industry which produces antibiotics will sell less to the Dutch dairy sector, however, they might widen their offer with alternative medicines to fill in the gap in their sales. The veterinarians suffer because they receive a margin over the antibiotics they sell. 1D expects that the veterinarians can also benefit by intensifying contact with the dairy farms to increase the animal health on the farm. Feed suppliers with alternative health diets or supplements will benefit from a larger market, as will the producers and developers of individual cow-sensors. Particularly the intensive dairy farms with a yield per cow will suffer since these farms usually have the highest antibiotics usage. The whole chain and the citizens will benefit since the milk will be produced with more eye for animal and human welfare.

Box 6: Alternatives for antibiotics

Respondent 4A expects a growth in the use of homeopathic medicines in the dairy sector, because of the maximum allowed dosing of antibiotics per animal per day. Homeopathic medicines do not account for the dosing of antibiotics and in addition to that the milk of the treated cow can still be processed and sold.

Another alternative for antibiotics was elaborated on by respondent 5B: Allicin. The substance allicin is found in garlic and has bactericidal, fungicidal, anti-viral and anti-parasitic properties. Allicin does not create antibiotic-resistant bacteria and according to 5B allicin has a higher success-rate in comparison with antibiotics when applied for mastitis: *"The success rate of antibiotics is 17 to 20 percent in case of clinical and sub-clinical mastitis, the success rate of allicin is 90 percent for these cases!"*

4.3.2. Potential solutions

4.3.2.1. Liquid fertilizer injection is used increasingly

Respondents 1C, 1F, 3A, 1E, 1D and 1A answered questions on this potential solution. 1D and 1F did not agree with the statement that liquid fertilizer injection would be used by more than 40% of the dairy farmers in 2025, the other respondents did. All these respondents did agree that the use of liquid fertilizer injection would increase amongst dairy farmers.

All respondents agreed on the fact that the main reason for this growth is the demand of dairy farmers for mineral efficiency. One motive is that when the mineral efficiency is high, dairy farmers perform well at the cycle indicator, which means they can use more manure on their own land. In addition to that, when the phosphate efficiency is high the dairy farmers are allowed to hold more cows with the same (recently announced) phosphate rights. Another motive is the cutting of costs, when fertilizer is used more efficient, the same yield can be achieved with less fertilizer or a higher yield with the same amount of fertilizer. A potential other motive for the future are additional environmental restrictions or rewards. The demand for precise placement of the fertilizer is in line with the demand for mineral efficiency. 1A stated that site-specific fertilization will become possible before 2025, causing a boost in the use of liquid fertilizer injection.

1A: "Site-specific fertilization will surely contribute to this development, because with this the mineral efficiency can be influenced positively much more."

Another reason for the growth of liquid fertilizer that was given by four of these respondents was the increased usage of waste-streams, however, 1D opposed to this because the waste-streams will only have a small local impact and will not take in larger shares of the fertilizer-market according to this respondent.

Obstacles for this development were found in the strong lobby of the granulate fertilizer industry, the difficult logistics of liquid fertilizer, the expensive application methods, the fact that it is not proven that liquid fertilizer injection gives an improved mineral efficiency, and the slow development of the application techniques. 3A does not agree on the points of the lobby and the difficult logistics, When the mineral efficiency is higher, these points will be no longer an issue for the development.

The impact of this growth will be large for the fertilizer industry, much more liquid fertilizer will be applied by the dairy farmers on their grassland. Also contractors will have more liquid fertilizer injectors to provide in the demand of the dairy farmers, which means the producers of these machines will benefit from this development.

4.3.2.2. Increased usage and valorisation of waste-streams

Respondents 1G, 3B, 1C, 1I, 2E, 2C, 1J, and 4F answered questions on this potential solution. All these respondents agreed with the prediction use and valorisation of waste-streams would increase in the future.

The major advantage of the use of waste-streams is that it saves produced fertilizer and thereby pollution is decreased since less production and transport is required. In general the waste-streams are also cheaper compared to produced fertilizer. Another advantage was recognized in a better cycle of streams, since waste-streams do not have to be produced and they exist anyway, no energy is lost in de production process. 3B expected that the image of the Dutch dairy farmer would improve when the use of waste-streams would increase because of the positive influence on the environment. 1I stated that waste-streams are often natural products, which would be

beneficial for the fertilizing of crops. A disadvantage is found in the compounds of waste-streams; often they are not homogeneous or they come with a low concentration of minerals with a fertilizing value. This disadvantage can be taken away be the valorisation of the waste-streams.

The steps that will have to be taken in order to make a significant increase possible are the following: First of all, a lot of legislation has to be changed. At this moment only a few waste-streams are legalized for the use as fertilizer, however, much more waste-streams could be used. In addition to that the legislation concerning the valorisation of waste-streams has to be changed so that creating waste-streams with a constant and useful composition can be created. Another step that has to be taken is more research after the efficiency of the waste-streams to ensure they are not performing worse than regular fertilizer.

At this moment waste-streams are valorised by manure intermediaries, but in the future it is most likely that the fertilizer suppliers will take place in valorising waste-streams because it will eat in on their own fertilizer sales. Other potential valorisation companies are specialized companies, cooperation of farmers, and small fertilizer producers.

The Dutch dairy chain is influenced by this development in the following ways: Dairy farmers benefit from a lower price and have more options with regards to fertilization of their fields. The fertilizer suppliers suffer from receding sales, but also have a business opportunity in the form of valorisation of waste-streams. The fertilizer producers also have receding sales in The Netherlands, however, these companies often are large multinationals so the effect will not be as large as for the fertilizer suppliers. Contractors will have to invest in injection machines, logistics and storage for the waste-streams, but on the other hand will create more employment for themselves by doing so. The producers of the waste-streams such as pig and chicken farmers have the advantage of less disposal costs or even a revenue stream in case of a popular waste stream. Direct cooperations between producer and user of the waste-streams are not expected to arise much, because an intermediary will almost always be in between, even when the waste stream does not have to be valorised. 1J thinks this is to blame on the individualistic attitude of the farmers:

1J: "History suggests that dairy farmers and pig farmers will not cooperate directly. Without intermediary they cannot even find each other for manure, something much more money is involved with!"

4.3.2.3. Site-specific fertilization

Respondents 1C, 2B, 2E, 2C, 1E, and 4F answered questions on this potential solution.

The respondents all agreed on the main advantage of site-specific fertilization; as much utilization of fertilizer as possible. 1E explained it as follows:

1E: "By providing in site-specific demand, the yield will increase as will the mineral efficiency. This will lead to less fertilizer per hectare."

Thinking further along this line, 1C stated that the mineral efficiency is also rewarded by the cycle indicator and the phosphate rights. The largest step that has to be taken before site-specific fertilization can come to practice is the development of the sensors that can determine the site-specific demand of plant and soil. When these are developed the translation between the data and the true demand will also be a hurdle to take. Machines that can apply fertilizer site-specific are already there, but are too expensive at the moment, this also has to be reduced before contractors and dairy farmers will use it. Five out of the six respondents on this issue expect site-specific fertilization to be in practice over 5 years, 2C however states it will already be in practice in 2017. 1E distinguishes between site-specific demand of the grassland and the soil; expecting site-specific demand determination of the grassland itself to be in practice within 5 years and site-specific demand of the soil taking more than 5 years to be in practice. On the question how much fertilizer site-specific application could save, the opinions were divided. 2C and 4F stated that dairy farmers will not apply less fertilizer, but yield more crop from their field. 1E opposed this by stating that with site-specific variation per 10 square meters, a saving of 20 to 30 percent of fertilizer is possible, which means the mineral efficiency would go up with the same percentage.

The site-specific demand will have a large impact on the Dutch dairy chain, especially on the beginning of the chain. When grass production goes up this means less additional feed has to be bought by the dairy farmers, causing a decrease of sale for the feed suppliers, especially for the protein-rich fodders. The fertilizer industry will of course also be influenced, when site-specific fertilization is in practice more liquid fertilizer will be used since the applying machines of liquid fertilizer are most suited for site-specific fertilizing. In general the environment

Box 2: High-pressure injection

Respondents 5A, 1B, 1H, and 1A answered questions on this machine.

A fertilizer machine that is already able to apply fertilizer site-specific is the high-pressure injector, because each nozzle can inject individually. This machine injects liquid fertilizer into the soil under high pressure, therefore, no parts of the machine have to go through or in the soil. This machine is not (yet) applied on dairy farmers grassland because of the high investment cost and the lack of site-specific demand sensors for grassland. In the arable sector however, this machine is applied with plant specific demand sensors for nitrogen. 5A states that the high pressure injector in comparison with the spoked-wheel fertilizer is lighter, able to perform a higher capacity, and still able to fertilize when the soil is hard because of drought. 1H states that the weight of this machine is still relatively high for application on grassland. The responses on when this machine would be applied on grassland in practice greatly differed across the respondents; 1H stated that this was completely dependent on when the site-specific demand sensors will be available, whereas 1B expects the machine to be in practice over 10 years. 1A expects it will even take 15 years before this machine is in practice with site-specific demand sensors for grassland. 5A thinks these sensors will be available much sooner and that the high pressure injector will be in practice on grassland in a few years, with a minimum of two years.

will be benefitted by site-specific fertilization, a development that is good for the dairy processors and retail as well.

4.3.2.4. Manure refinery in order to use it as fertilizer

Respondents 1G, 1C, 1I and 4E answered questions on this potential solution.

When manure refinery is developed to the level where it can process manure into fertilizer and is allowed to be used as fertilizer, there are several advantages to it: Less fertilizer is needed because more manure is used instead, therefore the manure-surplus will decrease. The manure is more efficient, this has a positive influence on the cycle indicator which means more cows are allowed with the same phosphate-rights. When farms still have to cope with a surplus, there will be a lot more of companies demanding refined manure and the refined manure can also be further transported.

The first step that has to be taken before refined manure can be used as fertilizer is the improvement of the processing-technique. This technique has to become more efficient to cut costs of the process and the output has to be comparable with fertilizer in terms of composition and mineral efficiency. In addition to that the legislation has to be changed, so that refined manure is allowed to be used on the expense of the usage of fertilizer.

The respondents did not have a shared vision on what companies will refine the manure. 1G thought that the fertilizer producers would take this up as soon as a profitable business case is realistic. However, this was opposed by 1C and 1I for the following reason:

1C: "As long as the manure-surplus is a Dutch problem, it will not be interesting for the large international fertilizer producers since the Dutch market is only a small fraction of the total market."

1I expected that several types of companies will refine manure; first of all specialized companies that solely focus on refining manure. Next to that there will be cooperations of farmers who will refine their own manure. Also the fertilizer suppliers will take up manure refinery because they will lose a lot of profit in the fertilizer sales as soon as refined manure is used as fertilizer. This last form is also expected by 4E. The respondents all expect refined manure as fertilizer in practice as soon as an efficient method and output is found. 1I expects this to be in five to ten years from now. 4E underlined the importance of the change in legislation that is necessary before refined manure can be used as fertilizer in practice, otherwise it would just be refined manure instead of manure.

The impact of this on the Dutch dairy chain will again be mainly on the beginning of the chain. Fertilizer producers and suppliers will suffer from decreasing fertilizer sales, but suppliers could become active in the manure refinery to find other revenue streams. New businesses might emerge with manure refinery as their core business. Arable farmers might benefit from the refined manure as well since it can be used as fertilizer and is expected to have a higher mineral efficiency compared to regular manure.

4.3.2.5. Increased protein yield per hectare grassland by smart fertilization

Respondents 4F, 4G, 1D, 1A, and 4E answered questions on this potential solution.

The effect of the current smart fertilization is for 3 out of the 5 respondents (4F, 4G, and 1D) too little to agree with this statement, however, when site-specific fertilization is in practice the same 3 respondents do agree. 1A however claims that increase of the protein content is already possible by applying the right form of nitrogen; ammonium nitrogen and amide nitrogen. In addition to that the precise placement and full coverage of the field should result in an overall increase in grass yield and thereby also protein yield. 1D expects that through a better timing of fertilization

the overall grass yield can also increase. The advantages of an increase in total grass yield and protein yield per hectare grassland (with the same amount of fertilizer) are the following: The environment and the mineral cycle are benefitted because less minerals are lost via emissions, the dairy farmers are allowed to have more cows because of a better mineral cycle. Another beneficial effect for the environment and the dairy farmer is that less protein-rich fodder has to be bought by the dairy farmers, causing less CO2 emission by production and transport of this fodder and cost savings for the dairy farmer. Thereby, the dependency on international feed sources will decrease, and dairy farmers will be more self-sufficient. On the question whether steps had to be taken the 3 aforementioned respondents reacted that site-specific fertilization had to be in practice first. This was opposed by the other 2 respondents, 4E stated the following:

4E: "With the current smart fertilization it is already possible to realize an increase in yield, by being more aware of the fertilization; dosing per field, accounting for pre-crop and soil-condition. Of course site-specific will increase the yield even further, but first the dairy farmer has to become more aware of the fertilization."

Other steps that have to be taken are a change in the mind-set of the consultants, who often try to sell their companies product instead of trying to help the dairy farmer achieve the highest yield possible. The infrastructure and storage of fertilizer has to be transformed to be suitable for liquid fertilizer.

The most direct impact on the chain is for the feed suppliers and producers who will sell less additional feed to the dairy farmers. As already stated above the dairy farms benefit from cost savings, allowance for more cows, and being more self-sufficient. The fact that dairy farmers can keep more cows is beneficial for all suppliers cause their market expands. In addition to that feed suppliers can have an advantage of selling more high quality fodder. Producers of smart fertilization machines will benefit from an expanding market because increasingly more dairy farmers will demand their contractor to fertilize with a smart fertilizer machine. Dairy farmers will be depending more on independent consultancy, because the feed and fertilizer suppliers have a mixed interest.

4.3.2.6. Robot fertilization

Respondents 1B, 2D, 2E, and 1A answered questions on this potential solution.

Robot-fertilization saves labour, causes less rutting because of the lighter machines, increases mineral efficiency because it can apply the fertilizer multiple times, and is more accurate. The downsides to this form of fertilization are the high price and maintenance cost, and it will be sensitive for malfunction. Fully automatic fertilization robots will take time to develop, for its development the automotive sector will be a leading example according to respondent 1A.

1A: "The developers of robot fertilizers will follow the developments of the automotive industry on robot-cars closely, since the resources of this industry enable much more progress."

The respondents did not agree on when the fully automatic fertilization robots will be in practice in the dairy sector. 1B stated that robots with the currently existing fertilization methods will be in practice within the coming ten years, and that site-specific fertilization robots will be in practice after those ten years. 1A expects fully automatic robots within fifteen years from now and 2E expects it to be over fifteen years. 2D expects that robot-fertilizers will not come to practice at all, because they will be too expensive.

The impact on the chain is found at machinery producers and –suppliers, contractors and of course dairy farmers. The machinery producers will have competition of the robot fertilizers or develop one themselves. The machinery suppliers will have a wider product range to offer but will also be left with fertilizers that are less bought because of the emerging robot fertilizer. Contractors will save labour, have less tractor operating work, and will need higher educated employees to keep the robot fertilizers operational. The dairy farmers benefit from the higher mineral efficiency these fertilizers can realize.

Box 4: Other future fertilizing techniques

Another fertilizing technique for the future might be drone fertilization. According to 1H and 3D this technique will cause no rutting at all, save labour, and enable the user to apply multiple small gifts of fertilizer which is preferred over one large gift. The drones have to developed towards fertilizing, and site-specific demand is required before this technique can come to practice. 1H states that this development can be enhanced by looking to developments in national defence, where drones are developed to carry large weights. Contractors would need less chauffeurs and more technicians for operation and maintenance of the drones.

1B mentioned a fertilizing technique that will take longer to develop, if it is developed at all. Drip irrigation, a system where tubes would be permanently in or on the grassland to apply fertilizer and water, is technique that would prevent drought, and increase yield potential by gradually providing moist and minerals according to the demand of the grass. Also with this technique no rutting will occur. Disadvantages will be the high cost of such a system and the tubes that are in or on the soil. 1B could not mention a timeline for this system coming into practice, because currently nobody is looking into it.

4.4. Analysis of the innovations

The spoked-wheel fertilizer and the disc-injection fertilizer will be analysed in this section. The external environment of these innovations will also be analysed. These analyses will be done by means of a SWOT-analysis followed by a TOWS-matrix.

4.4.1. Spoked-wheel fertilizer

First a SWOT-analysis of the spoked-wheel fertilizer is described based on the input that was provided by the respondents in the Delphi-study. Each factor is given a weight on a scale of 1 - 5 based on the importance in case of strengths and weaknesses and on likeliness to occur in case of opportunities and threats. These weights are based on the opinions of the respondents of the Delphi study. The output of the SWOT-analysis will be used to form a TOWS-matrix in order to assess what and how internal factors will interact with the external factors that were found during the SWOT-analysis.

4.4.1.1. SWOT-analysis

Strengths

Precision was mentioned as strength of the spoked-wheel fertilizer many times by the respondents. The precision of this machine comes forth out of the accurate dosage and placement of the fertilizer, the section closure which results in a minimal overlap, the ability to cover the full field including the sides and the headlands, This precision results in an increase of grass production per hectare due to a higher utilization of the nutrients because the whole field is fertilized, therefore, there are also less minerals lost to emission. As respondent 2E states: "The dosing and placement are extremely precise, besides, with the section closure no fertilizer is spilled into the environment". Because precision was the most mentioned strength in the first round of the Delphi, and the most appreciated strength amongst the respondents, the precision factor is given the weight of 5. Another strength of this machine is that it can *process liquids*, it enables the user to fertilizer with liquid fertilizer and/or with fluid waste-streams. Another advantage of liquid is that extra minerals can easily be added and mixed with the fertilizer in order to get a fertilizer that is composed exactly according to the needs of the crop. In addition to this, the ability to process liquid fertilizer also enhances the precision that can be achieved. Because of these reasons this strength is given a weight of 3. Respondent 1D thinks a cost-price advantage of liquid fertilizer should also be taken into account, however, 1F is certain that the granulate fertilizer industry will lower their prices in order to compete with the liquid fertilizer. That the spoked-wheel fertilizer is seen as a *proven technique* is because according to the respondents it is well developed, clean, robust and reliable. The technique of the machine has been proved functional over the last years, this is an important strength according to the respondents because of the cautious attitude of contractors and dairy farmers towards unproven techniques, however, when the results of a technique are better than the conventional, proof will very fast be generated. As respondent 1D stated; "the technique has been proven to work, however it has not been proven to be better". therefore this strength is given a weight of 2. The *little emission* is also seen as a strength because this means a higher utilization of minerals and it is beneficial for the environment. Reason for the little emission is the reduction of ammonia evaporation at the moment of appliance of the fertilizer. Another reason is that no great surpluses of minerals are created because there is no overlap on the field. The weight assigned to this strength is 4, because of the argument that respondent 1G gave; "the little emission is what distinguishes the spoked-wheel fertilizer from other fertilizing techniques". The fact that the fertilizer is *injected in the rootzone* is also a strength of this machine. The fertilizer is therefore closer to the plant which means it can be absorbed by the plant easier and quicker. The soil-structure is not cut with this technique and the injection needles even aerate the soil. Respondent 2C summarized this strength as follows: "The injection in the rootzone ensures a fast and easy uptake of the minerals, and it aerates the soil, but the downside is that the spokes wear down rapidly". Resulting in a weight for this strength of 3.

The strengths and corresponding weights are given in the following table:

Table 4: Strengths and weights spoked-wheel fertilizer

Strengths	*Precision*	*Little emission*	*Processing of liquids*	*Injected in rootzone*	*Proven technique*
Weights	5	4	3	3	2

Weaknesses

The weakness that was most often mentioned by the respondents was that the machine is *expensive.* The spoked-wheel fertilizer has a high purchase price, high maintenance costs, high operational costs, and is wear sensitive. This all causes that dairy farmers cannot buy and use a spoked-wheel fertilizer for themselves because it is not profitable. For all these reasons, the expensiveness is the largest weakness and weighed with 5. The fact that spoked-wheel fertilizing *has to be done by a contractor* because of price but also because of complexity is also a weakness. The dairy farmer is therefore dependent on the planning of the contractor and cannot control the appliance on the field. This weakness is assigned a weight of 2 since the need for outsourcing was also seen as an advantage for other respondents, respondent 4B stated the following consideration on this subject: "Of course it is a disadvantage that the dairy farmer is dependent on the planning of the contractor if he or she chooses for spoked-wheel fertilizing, however, it also saves labour and thereby creates room for more specialization". The *weight* of the spoked-wheel fertilizer is seen as a weakness since it can cause rutting in the field and requires a powerful tractor for operation, the weight given to this weakness is a 3, because as 2C (contractor with a spoked-wheel fertilizer) states: "Usually the planning allows to avoid fertilizing on wet fields, but in case of persistent rainfall or very wet fields the weight will cause rutting". The *capacity* of the spoked-wheel fertilizer is also a weakness because it is much lower compared with granulate spreading. This makes it hard to compete against the granulate spreaders and other fertilizer machines. In addition to this the spoked-wheel fertilizer is also more often troubled by malfunction, even further decreasing capacity. The low capacity accounts for a weight of 3, because the respondents perceive this as an important weakness, but definitely not as important as the expensiveness. Another weakness is that the machine *cannot apply* the fertilizer *site-specific*, with sensors currently being developed for site-specific demand analysis. The respondents agreed that not applying site-specific is not a large weakness at the moment, but will definitely be large when demand of crop and/or soil can be analysed site-specific. Therefore this weakness receives a weight of 4, as it is in the way of future diffusion of the spoked-wheel fertilizer. The s*pace between placement* of the injection is considered to be quite large according to a group of respondents, however, this is refuted by others who state the current placement is sufficient since the roots of grass grow "wide enough". Because of this contrast, this (potential) weakness is given a weight of 1.

The weaknesses and corresponding weights are given in the following table:

Table 5: Weaknesses and weights spoked-wheel fertilizer

Weaknesses	*Expensive*	*Not site-specific*	*Weight*	*Capacity*	*Has to be done by a contractor*	*Space between placement*
Weights	5	4	3	3	2	1

Opportunities

All the external factors that according to the respondents form opportunities for the success of the spoked-wheel fertilizer can be summarized by 3 thematic trends; dairy farmers focussing more on *resource efficiency* in order to get a better operating income, *more outsourcing and specialization* on dairy farms, and the increasing *attention for the environment* from the government but also in the sector itself. Since most of the aspects that were mentioned by the respondents point out the increasing importance of resource efficiency, this opportunity was given a weight of 5 for the likeliness to happen. The attention for the environment is also assigned a weight from 5, because the respondents *all* agreed this attention will increase during the years to come. The opportunity of the trend of more outsourcing and specialization was mentioned not as often as the other opportunities and was even doubted by some respondents because of the new restrictions of phosphate rights, as respondent 4F stated: "Less upscaling means less specialization". Therefore the weight for this opportunity is 2.

The opportunities and corresponding weights are given in the following table:

Table 6: Opportunities and weights spoked-wheel fertilizer

Opportunities	*Resource efficiency*	*Attention for the environment*	*More outsourcing and specialization*
Weights	5	5	2

Threats

The threats for the success of the spoked-wheel fertilizer that were recognized by the respondents are found in the *competition* amongst other fertilizing machines. The threat of competition is given a weight of 4, since it was recognized by most of the experts as a relative large threat. Respondent 1F stated aptly what the threat was: "Not only the granulate spreader, but also the granulates fertilizer themselves form a threat since this remains to be a reliable and payable fertilizer. Besides other alternative fertilizer methods will emerge". The threat of completion is underlined by the results of Porter's five competitive forces analysis. Another threat is the *mentality* of the dairy farmer, which is often focussed on cost-cutting and not always open for changes. The mentality is also not focussed on grassland-management. The weight for this threat is 3, since the respondents argued that when a technique evidently improves results, the mentality can be overcome. Dairy farmer 3A stated the following on this subject: "When a new technique proves to be better dairy farmers will look after the benefits minus the extra costs, not just at the extra costs." The *governments* form a threat on local, national and European level because the use of

fertilizer is under pressure and it is unclear how these governments will deal with this. However, there is a strong agricultural lobby, and a lot of the respondents expect that this threat is therefore relatively small, especially with the phosphate rights that are already restricting the dairy farmers' mineral use, therefore the weight for this threat is 1. *Liquid fertilizers* form a threat because the machine is only used with these liquid fertilizers and there are some disadvantages to them: The logistics are more complicated compared to granulate fertilizer, there is a limited offer of fertilizers and waste-streams, prices fluctuate much more, a lot of liquid fertilizers have a stronger acidifying effect and waste-streams are often not in the right composition available. Some of these arguments were countered by respondents who expected more offer of liquid fertilizers and waste-streams in the future compared with more treatment facilities to gain the right composition. The weight assigned to the threat of liquid fertilizers is 3, because the respondents were not certain how the developments around the liquid fertilizers and waste-streams will proceed, since it is also dependent on what types of waste-streams are allowed to be used and processed as fertilizer in the future. Another threat is seen in the strong *lobby of the granulate fertilizer producers and suppliers*, they will try to keep the liquid fertilizer out of the market as much as possible. This threat was mentioned often and recognized by most of the respondents, the likeliness to happen that is assigned to this threat is 5, because most respondents confirmed that this lobby is already active. Grundy's vector format also shows that this lobby is considered to be the most threatening force in the industry of the spoked-wheel fertilizer.

The threats and corresponding weights are given in the following table:

Table 7: Threats and weights spoked-wheel fertilizer

Threats	*Granulate fertilizer lobby*	*Competition*	*Mentality*	*Liquid fertilizers*	*Governments*
Weights	5	4	3	3	1

TOWS-analysis

All the internal and external factors that were found with the SWOT-analysis are placed in the TOWS-matrix below. In this matrix is shown how the strengths and weaknesses of the spoked-wheel fertilizer interact with the opportunities and threats in the external environment. A plus is symbol for a beneficial interaction for the spoked-wheel fertilizer, the more plusses the more beneficial the interaction. The opposite applies for the minuses. When a zero is depicted no interaction is expected by the researcher.

The strength precision shows a very positive interaction throughout the whole matrix, the precision aspect logically stands out when resource efficiency and the environment are taken into account. Since the precision strength is given a weight of 5, just as the opportunities resource efficiency and attention for the environment, the positive interaction weighs heavily. Another strength that stands out is the little emission that occurs when this fertilizing method is used, it is the strongest aspect with regards to the competition and the potential governmental restrictions. This strength has a weight of 4 and interacts positively with the opportunities and the threats that are most likely to occur according to the respondents.

The fact that the machine cannot place fertilizer site-specific is a weakness that complicates the seizing of the opportunities largely. Especially when the weights of the opportunities are taken into account, the ones that are most likely to develop interact most negatively. The expensiveness of the machine is an weakness that will make competing and changing the mentality of dairy farmers very hard, the weights of the competition and its lobby are the highest amongst the identified threats, therefore the expensiveness puts the spoked-wheel fertilizer in a position where the benefits of the method have to compensate the extra costs that are inherent for the spoked-wheel fertilizer.

The trend that dairy farmers will outsource and specialize on their cattle more relieves the weakness of weight and especially the fact that this method of fertilization has to be done by a contractor. The threats of the strong granulate fertilizer lobby and competition are the largest when the weights and interactions of the strengths and weaknesses are considered. The spoked-wheel fertilizer does not have any aspects that can relieve the threat of the disadvantages of the liquid fertilizers, the precision compensates a little in case of fertilizers or waste-streams with a low mineral efficiency.

TOWS Matrix Spoked-Wheel Fertilizer			Strengths					Weaknesses					
			precision	little emission	processing of liquids	injected in rootzone	proven technique	expensive	not site-specific	weight	capacity	has to be done by contractor	space between placement
			5	4	3	3	2	5	4	3	3	2	1
Opportunities	resource efficiency	5	+++	+++	++	+	+	--	---	-	-	-	-
	attention for the environment	5	+++	+++	+	++	0	0	---	-	--	-	-
	more outsourcing and specialization	2	++	0	+	+	0	-	--	+	-	++	0
Threats	granulate fertilizer lobby	5	++	+++	-	+	++	---	0	---	---	--	-
	competition	4	++	+++	+	+	++	---	-	--	--	--	-
	mentality	3	+	+	+	0	++	---	0	-	-	--	0
	liquid fertilizers	3	+	0	0	0	0	-	--	0	0	-	-
	governments	1	++	+++	++	++	+	0	--	0	0	0	-

Figure 18: TOWS Matrix Spoked-Wheel fertilizer

4.4.2. Disc-injection fertilizer

A lot of internal and external factors of the disc-injection fertilizer are similar to the factors of the spoked-wheel fertilizer, those will not be further elaborated but only mentioned as factor.

4.4.2.1. SWOT-analysis

Strengths

Precision and the *processing of liquids* are the same strengths as at the spoked-wheel fertilizer, therefore they also receive the same weight; 5 and 3. For *injection in the rootzone* and *little emission* this is partly true. The injection by the disc-injection fertilizer puts the fertilizer in the rootzone but it does not spare the soil-structure as it cuts through the soil. As respondent 1B states: “Of course injection in the rootzone is in principal a strength, however, when it cuts through

the soil one can question if it is still beneficial for the yield of grass". Because of this the weight of the 'injection in the rootzone' strength is only 1. The respondents do expect less emission compared to granulate spreading, but think the spoked-wheel fertilizer is better at this, respondent 2B explains why: "The fertilizer is still partly exposed to the open air as it stands in the cut in the soil, therefore, some emission might still occur. For this reason the weight of 'little emission' was given a 2. The *value for money* of this machine is seen as a strength by some of the respondents, especially when compared to the spoked-wheel fertilizer. This strength is assigned a 4 because as respondent 1A states; "this is the strength that distinguishes the disc-injection fertilizer from other liquid fertilizer injectors". Another strength is the *robustness* of the technique on this machine; it has been proven over many years for applying manure, the fluids only make contact with the tank and tubes, and it is perceived to be a solid construction. The weight assigned to the robustness is a 3, because some respondents argued the durability of the machine. The fact that this technique can be *combined with manure spreading,* so applying manure and fertilizer at the same time is possible, is also a strength according to some of the respondents, this strength is given a weight of 2 because a few other respondents state that the timing of the application in that case would often not be ideal and in addition to the weight of the machine would increase even more.

The strengths and corresponding weights are given in the following table:

Table 8: Strengths and weights disc-injection fertilizer

Strengths	*Precision*	*Value for money*	*Processing of liquids*	*Robust*	*Little emission*	*Combinable with manure spreading*	*Injected in rootzone*
Weights	5	4	3	3	2	2	1

Weaknesses

Expensive, has to be done by the contractor, not site-specific, weight, capacity and the *space between placement* are weaknesses of the disc-injection fertilizer that are already described for the spoked-wheel fertilizer. However, the expensiveness differs between both machines; the disc-injection fertilizer is significantly cheaper according to the respondents. Therefore this weakness is given a weight of 3 instead of 5. The weakness of has to be done by a contractor remains the same; 2. Also for not site-specific the same weight is given; 4. The weight of the disc-injector is not as high due to the smaller tank on the machine, this causes the weight of this weakness to decrease to 2. However, the smaller tank causes capacity to go down as well, the weight for this weakness therefore increases to 4. The space between placement of the disc-injection fertilizer is also weighed with 1, just as for the spoked-wheel fertilizer. Another weakness of the disc-injection fertilizer is that the technique has *not proven* itself with regard to applying fertilizer: "It is unknown how well the minerals are utilized with the disc-injection method", says 1D. Therefore this weakness is weighed with 4. Some of the respondents expect the *emissions* to be *relatively high* since some of the liquid is still exposed to the open air, because of this, a large beneficial effect of injection is lost, since the importance of emission and given the fact that this weakness cannot be overcome the weight for this weakness is 4. The fact that the machine *cuts through the soil* is considered a major weakness of this machine since it damages the soil structure, this would reduce yield and thereby resource efficiency, the weight assigned to this is 5, because it was the

most mentioned weakness and the consequences of it (less yield thus less mineral efficiency) oppose to the goals of smart fertilization.

The weaknesses and corresponding weights are given in the following table:

Table 9: Weaknesses and weights disc-injection fertilizer

Weaknesses	*Cuts through soil*	*Not proven itself*	*High emissions*	*Capacity*	*Not site-specific*	*Expensive*	*Has to be done by the contractor*	*Weight*	*Space between placement*
Weights	5	4	4	4	4	3	2	2	1

Opportunities

As the external environment for the spoked-wheel fertilizer and the disc-injection fertilizer are almost identical, no other opportunities were mentioned by the respondents, therefore the opportunities and the corresponding weights are: *resource efficiency (5)*, *attention for the environment (5), and more outsourcing and specialization (2)*.

Threats

The threats are also identical for both of the machines, these are: the *lobby of the granulate fertilizer producers and suppliers (5)*, *competition (4), mentality* of the dairy farmer (3), *liquid fertilizers (3)*, and *governments (1)*.

4.4.2.2. TOWS-analysis

The TOWS matrix for the disc-injection fertilizer is shown below in Figure 15. The strengths that and weaknesses that both machines possess do not have the same interactions with the opportunities and threats because of the different weights that have been assigned to them.

The strengths of precision and processing of liquids have the same interactions since the weights are the same as for the spoked-wheel fertilizer. The strength of little emission and injected in rootzone however have less weight compared to the spoked-wheel fertilizer, therefore their interactions are also less positive. The strengths of the disc-injection fertilizer that were not recognized for the spoked-wheel fertilizer give the disc-injection fertilizer some competitive advantage. The value for money strength has a strong positive interaction with the threat of competition. The fact that this method can be combined with manure spreading has positive interactions with all external factors except for the threat of the liquid fertilizers.

The weaknesses has to be done by a contractor, not site-specific, and space between placement have the same weight assigned as for the spoked-wheel fertilizer. Because the disc-injection fertilizer is less expensive the interactions are also less negative, the same effect is applicable for weight. But, as stated above, the lower weight is at the expense of the capacity of the machine, therefore the interactions between capacity and the external factors are also more negative. The weaknesses that do not apply for the spoked-wheel fertilizer, not proven itself, relatively high emissions, and cutting through the soil, have a very high weight and show strong negative

interactions with all external factors. These last mentioned weaknesses give the machine a severe disadvantage when the comparison is made against the spoked-wheel fertilizer.

TOWS Matrix Disc-Injection Fertilizer			Strengths							Weaknesses								
			precision	value for money	robust	processing of liquids	combinable with manure spreading	little emission	injected in rootzone	cuts through the soil	capacity	not site-specific	not proven itself	high emissions	expensive	has to be done by contractor	weight	space between placement
			5	4	3	3	2	2	1	5	4	4	4	4	3	2	2	1
Opportunities	resource efficiency	5	+++	+	+	++	++	++	+	--	-	---	--	---	--	-	-	-
	attention for the environment	5	+++	0	+	+	++	++	+	--	---	---	-	---	0	-	-	-
	more outsourcing and specialization	2	+	0	+	+	++	0	+	-	-	--	--	--	-	++	+	0
Threats	granulate fertilizer lobby	5	++	++	++	-	++	++	+	---	---	0	---	-	--	--	--	-
	competition	4	++	+++	++	+	++	++	+	---	---	-	---	--	--	--	--	-
	mentality	3	+	++	+	+	+	+	0	---	-	0	--	--	--	--	-	0
	liquid fertilizers	3	+	0	0	0	0	0	0	0	0	--	-	--	-	-	0	-
	governments	1	++	0	0	++	+	++	+	--	0	--	--	---	0	0	0	-

Figure 19: TOWS Matrix Disc-Injection Fertilizer

5. Conclusions and Recommendations

This chapter will provide the answers to the central research question and the specific research questions that were stated at chapter two of this research. These questions will be answered based on the results that were found during the literature study and the Delphi study. Firstly the specific research questions will be answered which will lead to the answer on the general research question.

5.1. Answering the specific research questions

In this section the specific research questions will be answered based on the results that were gained by this study. For answering SRQ 1 the results of the following analyses will be used; SWOT-analysis, TOWS-analysis, and Porters five competitive forces. These results can be found in section 4.4. (SWOT and TOWS) and 4.2. (Porters five competitive forces). The Business Model Canvas (section 4.1.), and the challenges and potential solutions (section 4.3.) will be used for answering SRQ 2 and 3.

5.1.1. Specific Research Question 1

Which of the two innovations could become successful in the Dutch dairy chain and thereby help this chain become more sustainable?

In order to actually help the Dutch dairy chain become more sustainable, the use of the innovation will have to be diffused successfully amongst the contractors and dairy farmers. Both of the innovations at issue will be examined individually based on their potential to become successful and thereby help the Dutch dairy chain to become more sustainable.

5.1.1.1. SRQ 1a: Does the spoked-wheel fertilizer meet the required criteria in order to become successful and thereby help develop the Dutch dairy chain sustainably?

The results of the SWOT- and TOWS-analysis in section 4.4. show that the spoked-wheel fertilizer possesses two strengths that deal very well with the opportunities and threats that are most likely to occur. The precision of the machine interacts positively with all opportunities and threats whereas the relatively little emission that is produced when this machine is used strongly interacts positively with the opportunities of resource efficiency and attention for the environment as well as the threats of competition and the granulate fertilizer lobby. According to this study the expensiveness of the spoked-wheel fertilizer is the largest weakness and has a strong negative interaction with the threat of competition and the granulate fertilizer lobby. A weakness that is expected to trouble the success of the spoked-wheel fertilizer on the long term is the lacking of site-specific application of fertilizer. This study has shown that as soon as the sensors for site-specific demand of crop and/or soil are in practice, site-specific application will be a demand for the resource efficient and environmentally friendly users. When the producers and developers are able to come up with a spoked-wheel fertilizer which is able to apply fertilizer site-specific by the time the site-specific demand sensors are in practice, the potential success of this machine is large since this development will increase the most important strengths of the machine as well: Even more precision and even less emission will result into a higher mineral efficiency, automatically increasing the crop yield per hectare, and thereby also increasing the competitive advantage. This increased competitive advantage is needed to compete against the largest threat that was found by Porters five competitive forces model (section 4.2.) in this study; the strong position of granulate spreader producers which are backed by the strong lobby for

granulate fertilizer. Other competitive forces that have been described in this study are substitutes such as the high pressure injection fertilizer, the strong bargaining power of sensor and software suppliers, and the decreasing price-performance trade-off as the standard performance level increases. These forces are expected to be dealt with when the developers and producers of the spoked-wheel fertilizer succeed in improving their machine with site-specific application, with the important footnote that the price of the machine does not increase to a unacceptable level. The maximum price cannot exactly be estimated, since the exact beneficial effects of site-specific fertilization on grassland cannot be determined yet, which means a cost-benefit analysis cannot be made yet. The price-performance trade-off of this machine with site-specific fertilization is expected to be beneficial to dairy farmers based on this study, since they have to be as efficient as possible with the available minerals, land and crops. Another reason for the expected success is that the current substitute which can apply site-specific, the high pressure injector, is very expensive at the moment and not developed yet for appliance on grassland of dairy farms.

All results considered, the spoked-wheel fertilizer meets the requirements of becoming a successful fertilizer machine in the Dutch dairy chain, when the machine in the future will be able to apply fertilizer site-specific with a positive price-performance trade-off. If this is not the case, the spoked-wheel fertilizer will be substituted by machines which are able to apply fertilizer site-specific.

When the spoked-wheel fertilizer is able to apply fertilizer site-specific and thereby does succeed on the long term in the Dutch dairy chain, it will most surely help develop the Dutch dairy chain sustainably since the mineral efficiency and the emission are all changed for the better.

5.1.1.2. SRQ 1b: Does the disc-injection fertilizer meet the required criteria in order to become successful and thereby help develop the Dutch dairy chain sustainably?

The results show that the strength of precision and the positive interactions with the external factors are also relevant for the disc-injection fertilizer. However, the little emission has less positive interactions compared to the spoked-wheel fertilizer which means the competitive advantage in comparison with traditional fertilizers at this aspect is smaller. The results show that the respondents perceive the value for money of the spoked-wheel fertilizer to be a strength, this compensates for the competitive advantage partially. The machine is combinable with manure spreaders, enabling contractors or dairy farmers to execute applying both at once, this is seen as a Unique Selling Point but also complicates the timing of appliance. The weakness of expensiveness is also relevant for the disc-injection fertilizer, however, this weakness was given less weight in comparison to the spoked-wheel fertilizer. The disc-injection fertilizer is also not able to apply fertilizer site-specific, and as stated above; this is seen as a crucial requirement for the future of 'smart' fertilizers. According to this study the weaknesses that really obstruct the successful diffusion of the disc-injection fertilizer in the Dutch dairy chain are; the machine cuts through the soil, has relatively high emissions, and has not proven itself. The TOWS-analysis shows that these weaknesses have a strong negative impact on all the external factors and for the relative high emissions and cutting through the soil no solutions will be at hand since it is inherent to the method of application. The competitive forces are exactly the same as for the spoked-wheel fertilizer, since the machines are in the same industry. However, for the disc-injection fertilizer site-specific appliance of fertilizer is not the only obstacle in the way of competing in this industry on the long term; the relative high emission, and cutting through the soil also are expected to obstruct successful diffusion on the long term based on this study. On the short term the unproven status of the disc-injection fertilizer is expected to slow down the diffusion of this machine.

At this moment the machine is not produced in a production line but build by hand by adapting a second hand manure disc-injector. Given the results of this study, the disc-injection fertilizer is not a fertilizer injector which will be widely used in the Dutch dairy chain because it has to many deficiencies. Some of these deficiencies might be overcome such as site-specific appliance of fertilizer and the unproven status, however, when the (for a 'smart' fertilizer) high emissions and the cutting through the soil are dealt with, the machine will change radically and it will no longer be a disc-injection fertilizer. On the short term this machine might help out some contractors that want to start injecting liquid fertilizer but not willing to invest as much as is needed for a spoked-wheel fertilizer. On the long term however, this machine is not expected to play a significant role in the rise of smart fertilization based on this study. Because of this the conclusion has to be drawn that the disc-injection fertilizer does not meet the required criteria to be successful and thereby will not be able to help change the Dutch dairy chain sustainably.

5.1.2. Specific Research Question 2

What might be the impact of the spoked-wheel fertilizer and/or the disc-injection fertilizer on the business model of Dutch dairy farms and the existing business models active in the fertilizer industry and fertilization industry operating in the Netherlands?

This section will answer the questions on what the impact of the innovations at issue might be, in case these innovations diffuse successfully in the Dutch dairy chain. Since the results provided the same business model for both the spoked-wheel fertilizer and the disc-injection fertilizer the impact of the innovations does not have to be answered for each innovation individually. Besides the business model canvas some of the challenges and potential solutions are used for answering these questions since they give further insight on consequences of increased use of liquid fertilizer injectors.

5.1.2.1. SRQ 2a: What is the business model of the producers of the spoked-wheel fertilizer and the disc-injection fertilizer?

The business model of the innovations is described in results-section 4.1. of this report. The results showed that the business model of the disc-injection fertilizer and the spoked-wheel fertilizer are the same. This specific research question is fully answered by the Business Model Canvas that is shown in the abovementioned section.

5.1.2.2. SRQ 2b: What impact can be expected on the use of resources in this part of the Dutch dairy chain?

The most obvious change in the use of resources due to an increased use of liquid fertilizer injectors is the increase of the use of liquid fertilizer. The type of liquid fertilizer however could not be clearly indicated by the respondents, but it surely would have a high mineral efficiency. Another resource that would be used more according to the respondents are waste-streams, a development described in section 4.3.1.2. Since these fertilizer-replacers have no production cost, besides eventual valorisation, the price is often lower. The use of waste-streams is also beneficial for the environment, because there is no specific production process in place for this stream, no CO_2 –equivalents are produced by the creation of the waste-streams. The increased use of liquid fertilizers and liquid fertilizer replacers such as waste-streams lower the use of granulate fertilizer since the use of fertilizer is limited on dairy farms. Another resource that is influenced by the increased use of liquid fertilizer injectors is labour. Since the results in section 4.3.1.1. show that most liquid fertilizers will be operated by contractors and hardly ever by dairy farmers themselves, the outsourcing of labour is expected to increase on dairy farms. This is a development that was also recognized by the respondents as an opportunity for the liquid

fertilizer injectors. A higher mineral efficiency due to the use of liquid fertilizer injectors is not supported by all respondents at the moment, however, in case of site-specific fertilization all respondents do expect a higher mineral efficiency (sections 4.3.2.1. and 4.3.2.3.). The fact that the field is fully covered with fertilizer and the overlap is reduced to a minimum already has a positive influence on the mineral efficiency. The impact of a higher mineral efficiency on the use of resources is as follows:

- Less fertilizer is required per hectare
- The crop and protein yield per hectare increases
- A decrease of required additional feed on dairy farms
- The utilization of fuel will increase when the use of liquid fertilizer injectors increases

5.1.2.3. SRQ 2c: What companies might be affected by the innovations in this part of the Dutch dairy chain?

For each business model that might be changed, the changes will be discussed per block of the Business Model Canvas. These changes have been described in Results section 4.1. When more liquid fertilizers are used in the Dutch dairy chain, this study has shown that the business model of contractors changes:

- More contractors will change their value proposition towards dairy farmers by adding the benefits of liquid fertilizer injection.
- The key partners of contractors are also changed by adding the liquid fertilizer producer, the liquid fertilizer supplier, the waste-stream valorisation company, and the manure processor for the supply of liquid fertilizer or manure.
- Liquid fertilizer injecting is added to the key activities of the contractor
- Liquid fertilizer and fertilization creates a revenue stream but also additional costs.

Another business model that is changed according to the respondents is the one of the fertilizer suppliers:

- The granulate fertilizer sales will reduce and the fertilizer supplier will also start selling (more) liquid fertilizer and start the valorisation of liquid waste-streams, which is currently done by manure intermediaries.
- The value proposition of fertilizer suppliers is also changed by adding the benefits that liquid fertilizer and waste-streams will bring the dairy farmers.
- The producers of liquid fertilizers and waste-streams are added to the key partners of the fertilizer suppliers.
- The valorisation of waste-streams and composing of liquid fertilizer is added to the key activities.
- Extra costs are of course created by these activities, and an additional revenue stream is the purpose of all these changes to the business model of the fertilizer suppliers.

Besides these two business models that are changed significantly, there are also business models which see an in- or decrease of their sales according to the results of this study:

- Liquid fertilizer suppliers, liquid fertilizer producers, manure processors, and waste-stream valorisation companies see an increase in demand due to the increased sales of liquid fertilizer injectors.
- Dealers of machinery see an increase in sale of liquid fertilizer injectors and an increase of maintenance for these machines.
- A decrease of sales of granulate fertilizer spreaders is expected, however, these machines require much less maintenance.

- The producers of the liquid fertilizer injectors will have an increase of sales, sales of parts, maintenance, consultancy, data-sales, calibration, lease, repairs, and contracting.
- Besides the granulate fertilizer suppliers also the producers of the granulates and the granulate spreaders have to deal with a decrease in demand in the Dutch dairy chain.
- Other parties that will suffer are the developers of other (smart) fertilizer machines, such as the high pressure injector.

5.1.3. Specific Research Question 3

What is the effect of the potential solutions on the capability of Dutch dairy farmers to deal with the challenges and regulations they face?

In the results section 4.3. the challenges and the potential solutions in the Dutch dairy chain and the effects of these have been described, thereby the specific research questions of 3a and 3b are already answered. In this section the impact of these developments on the actors in the Dutch dairy chain will be described, this will answer specific research question 3c: What is the potential impact of these challenges and solutions on the Dutch dairy farmers, the fertilizer industry and the fertilization industry operating in the Netherlands?

5.1.3.1. Challenges

5.1.3.1.1. Phosphate rights

The impact of this challenge on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Dairy farmers without a successor will quit on the shorter term since an extra source of money becomes available by selling the phosphate rights.
- Land prices are expected to stabilise instead of increasing further.
- The impact on grazing remains unclear since the respondents differed strongly on this point.
- All companies that deliver supplies or services towards dairy farmers suffer from the introduction of phosphate rights since the market will not grow as expected.
- Dairy processors and retailers also suffer from less national milk supplies, which might increase the milk price.

5.1.3.1.2. Manure legislation might be changed

The most progressive method that was suggested is to set use limits based on the mineral efficiency of the individual farm. The impact of such a method for manure legislation will be the following according to the results of this study:

- The dairy farmers will strive for a mineral efficiency that is as high as possible; beneficial for the dairy farmer, but also for the environment and the ground water in particular.
- This change would create a larger market for suppliers of mineral efficiency increasing methods, machines and supplies.
- The image of the Dutch dairy chain will also improve because less pollution will occur.

5.1.3.1.3. A low CO_2 (-equivalent) footprint per kilogram milk will be rewarded, and compulsory reduction of greenhouse gas emissions

These two challenges can be concluded upon at once, since the consequences are the same. The respondents did not agree upon whether a reward system, punishment system, greenhouse gas

ceiling, or a combination of these will be the used method in the future, but all respondents did agree that greenhouse gas reduction will be required in the Dutch dairy chain. Whatever method will be used, the dairy farmers will pursue a lower emission of greenhouse gasses and to achieve this they will invest in reduction methods. The impact of this development on the actors in the Dutch dairy chain will be the following according to the results of this study:

- The companies that can supply technologies, constructions, methods, and consultancy for greenhouse gas reduction will benefit from an increasing market.
- The whole Dutch dairy chain benefits from these greenhouse gas reductions and the dairy processors have a competitive advantage compared to foreign processors.

5.1.3.1.4. Grazing

It remains quite uncertain how grazing will develop in the future for the Dutch dairy chain. However, it is certain that the grazing issue will play an important role. The sector has stated a goal of 80 percent of the cows grazing, and the current percentage is approximately 70. The respondents disagreed upon whether the sector would reach their goal without governmental interference. The dairy processors will keep paying a premium for 'grazing-milk' to stimulate grazing but it cannot be said if this will be enough to accomplish the goal. Governmental interference will likely occur in case the goal of 80 percent is not reached, because grazing cows are considered to be cultural heritage. Mineral efficiency is decreased in case of grazing and ammonia emission is reduced. Expected is that the environment is not harmed nor benefitted by grazing. More grazing will improve the image of the Dutch dairy chain and will be beneficial for the value proposition of dairy processors and retailers.

5.1.3.1.5. Use of preventive antibiotics is reduced

A total ban of preventive antibiotics in the Dutch dairy sector is not to be expected, however, further reduction seems inevitable. Most likely is a reduction of maximum allowed dosing per animal per day. The impact of this challenge on the actors in the Dutch dairy chain will be the following according to the results of this study:

- It is detrimental for veterinarians as they currently profit from the sales of antibiotics, whereas alternative medicines are often not bought via the veterinarians.
- Pharmaceuticals will also suffer from a decrease in sales of antibiotics but are also considered to become players in the alternative medicine sector.
- The whole Dutch dairy chain will benefit from a better image if less antibiotics is used because of the beneficial effect for the humane care sector.
- Of course companies that sell alternative medicines will benefit from an increase in demand and thereby sales.
- Producers and suppliers of healthy feed diets or supplements will also benefit from increased demand since preventive health care for cows will become more important as the use of antibiotics is reduced.

5.1.3.2. Potential solutions

5.1.3.2.1. Liquid fertilizer injection is used increasingly

The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Contractors change their business model by offering liquid fertilizer injection
- Fertilizer suppliers start valorising waste-streams and supplying waste-streams and liquid fertilizer.
- Injector producers, machinery dealers, liquid fertilizer producers, manure processors, waste-stream valorisations companies, and liquid fertilizer suppliers will benefit from increased revenue streams.
- Granulate fertilizer producers, - suppliers, and the producers of the granulate spreader will see a decrease of sales.

5.1.3.2.2. Increased usage and valorisation of waste-streams

The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Companies that might take up valorisation of waste-streams are fertilizer suppliers, companies completely specialized on valorisation, cooperations of farmers, and small fertilizer producers.
- The fertilizer suppliers and small fertilizer producers might start the valorisation of waste-streams because their market share of fertilizer shrinks too much. For larger fertilizer producers this will not be the case since this are large multinationals and it is not expected that valorisation of waste-streams will take off in foreign countries in the near future.
- More contractors will be investing in injection machines, logistics and storage for the waste-streams and thereby creating more employment.
- Waste-stream producers have less disposal-costs or even a revenue stream from their waste-stream.
- An intermediary company will (practically) always be between the producer and the end-user of the waste-stream.

5.1.3.2.3. Site-specific fertilization

The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- The environment will be benefitted since there is less emission and leeching, causing the whole Dutch diary chain gaining a better image.
- Granulate fertilizer producers, - suppliers, and – machinery producers will suffer from this development as they cannot lift on the emergence of site-specific application of fertilizer.
- Feed producers and suppliers suffer from decreasing sales of protein-rich additional feed.
- All companies selling, valorising, or producing liquid fertilizers, waste-streams, or machines that apply these site-specific will logically benefit from this development due to increasing sales.

5.1.3.2.4. Manure refinery in order to use it as fertilizer

The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Companies that might start refinery of manure are; fertilizer suppliers (since they lose sales of fertilizer), specialized manure refineries, and cooperations of farmers.
- The beginning of the Dutch dairy chain is influenced by this development as the fertilizer producers and suppliers lose market share.

- Arable farmers might benefit from the development as the refined manure is expected to be more efficient and can be used in the usage of artificial fertilizer.

5.1.3.2.5. Increased protein yield per hectare grassland by smart fertilization

With the current methods that are available this statement was doubted by 3 out of the 5 respondents that responded on this solution. The two other respondents were sure that it already is possible with the current methods. All agreed that when site-specific fertilization is in practice this will be a (partial) solution for increasing yield and thereby mineral efficiency. The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Dairy farmers will be more self-sufficient, thereby will need less additional feed, will be allowed to have more cows because the mineral efficiency goes up, and will cut costs as a result of all this.
- The granulate industry will suffer since smart fertilization will be mostly executed with liquid fertilizer.
- Feed suppliers and producers will also suffer from decreasing sales of additional feed, however, they might benefit from selling higher quality fodders.
- Producers of smart fertilizer machines and contractors will benefit from the increasing demand.
- Independent consultancy becomes increasingly important since the consultancy of feed suppliers often comes with mixed interests.

5.1.3.2.6. Robot fertilization

The impact of this solution on the actors in the Dutch dairy chain will be the following according to the results of this study:

- Machinery producers will have competition or produce these robot-fertilizers themselves.
- Machinery suppliers will have a wider product range but are also left with outdated fertilizers.
- The business model of contractors will change severely; less tractor operators are required and more higher educated employees are needed to keep the robots functioning.
- The value proposition of contractors can also be changed for the better by adding the advantages of robot fertilization to their services.
- Dairy farmers can benefit from the increased mineral efficiency and also improved yield since less rutting occurs, this is of course also beneficial for the environment.

5.2. Answering the general research question:

What might be the impact of the spoked-wheel fertilizer and the disc-injection fertilizer the dairy farms, the fertilizer industry, and the fertilization industry operating in the Netherlands?

This study has shown that the fertilization innovations which are the focus of this research will stimulate the development of smart fertilization in the Dutch dairy sector, on the condition that they become successful in this sector. The consequence of this stimulant is that the use of liquid fertilizer will increase which directly decreases the use of granulate fertilizer. According to the respondents, contractors will have more employment when they invest in these (successful) fertilizer injectors because dairy farmers outsource the injection of liquid fertilizer, this in

contrast with granulate fertilization which they often do themselves. In case of one or both innovations become a success in de Dutch dairy sector then the use and valorisation of waste streams for grassland will also increase. The mineral-efficiency of the fertilizer is expected to increase by using the innovations which results in less detrimental effects for the environment and an increased yield per hectare grassland. An increased mineral efficiency also means that dairy farmers are allowed to apply more manure and keep more cows because less phosphate is excreted per cow. The respondents expect the business models of (artificial-) fertilizer-suppliers and contractors to change radically since the supply and application of liquid fertilizer will become one of the Key Activities of these enterprises. Besides that, liquid fertilizer suppliers, liquid fertilizer producers, manure processors, and waste-stream valorisation companies are expected to benefit from an increased demand for their products and services whereas feed suppliers, granulate fertilizer suppliers, granulate fertilizer producers, granulate spreader producers, and competitors of the innovations will see a decrease in the demand for their products and services according to the respondents.

The abovementioned impact is the result of successful diffusion of one or both of the fertilization-innovations. This research has shown that the spoked-wheel fertilizer has the best credentials for becoming successful in the Dutch dairy sector, because, on the short term the spoked-wheel fertilizer is the most precise and efficient compared to all other fertilization methods, and on the (medium-) long term the spoked-wheel fertilizer only needs to be developed so that it can apply fertilizer site-specific. The disc-injection fertilizer on the other hand has too many and too weak characteristics according to the TOWS analysis in this study, that it is not expected that this fertilization method will be a widely used method in the Dutch dairy sector.

The potential impact of the challenges and potential solutions that have been analysed in this research is very diverse, however a clear red line was recognized. All these developments that relate to fertilizers or fertilization have one thing in common: Mineral efficiency. This study has shown that the challenges and solutions create the possibility to or demand an increase of mineral efficiency. According to this study the current and future challenges that increase the demand for mineral efficiency are:

- Phosphate rights
- Reduction of greenhouse gas emission (forced or via rewarding)
- Farm-specific manure legislation (potentially)
- Land-based farming (see Theoretical Framework)
- Manure processing obligation (see Theoretical Framework)

The solutions that enable realisation of increasing mineral efficiency according to this study are:

- Liquid fertilizer-injection is applied more (also more availability)
- The use and valorisation of waste streams increases
- Site-specific demand analysis and fertilization
- Manure processing into fertilizer
- Smart fertilization increases the (protein-) yield of grassland
- Robot fertilization

Besides the abovementioned developments grazing and reduction of antibiotics-usage were also analysed in this research. Upon the future regarding grazing can be concluded that the goal of 80% will most likely be achieved. In case the Dutch dairy sector does not achieve this goal with own measures, then it is expected to be achieved with help or obligation from the Dutch government.

The reduction of antibiotics-usage will be accompanied by the increased usage of alternative medicines and an improving health-monitoring of the animals.

All results considered the major challenge for the Dutch dairy sector is **resource efficiency;** efficiently handling the available minerals, land, crops, animals, medicines, labour and capital. The suppliers of Dutch dairy farmers have to increase their own resource efficiency and have to enable the Dutch dairy farmers to increase their resource efficiency as well. The challenge for resource efficiency comes from two sides; the environment and the profitability. For the environment an increase of the resource efficiency is essential, when the resources are utilized as efficient as possible, as little as possible spillage which pollute the environment remains. For the profitability of dairy farms the resource efficiency is equally important, since it is a direct indication of the profitability of the enterprise. After all, an improved production with less resources means a higher turnover with less costs. All the developments that were analysed during this research bring the Dutch dairy sector, the fertilizer-industry and the fertilization-industry towards a more sustainable and efficient chain. Not only these industries benefit from these developments, also the dairy processors, retailers, consumers and the environment.

5.3. Recommendations

This research enabled the researcher to do several recommendations for the fertilizer-producers and –suppliers, fertilization-producers and –suppliers, contractors and dairy farmers.

The fertilizer-producers are advised to diversify their product-range. Since the use of liquid fertilizer is expected to grow in the Dutch dairy sector, it is wise to invest in this market. An important point of attention when investing in liquid fertilizers has to be the research after the mineral efficiency of the fertilizers. The fertilizers with the highest efficiency are the most interesting for the dairy farmers and provide the fertilizer producers with an competitive advantage compared to other fertilizer producers.

For the fertilizer-suppliers the recommendation is largely the same as for the fertilizer-producers. When they widen their product-range with liquid fertilizers, they respond to the growth in the usage of liquid fertilizer. The price and availability of the fertilizer logically remain important aspects, however, the mineral efficiency is expected to become increasingly important for the dairy farmer and therefore it should be part of the consideration of the choice for a certain fertilizer. By demanding efficient fertilizers from the fertilizer-producers the fertilizer-supplier is enabled to distinguish themselves in the market.

For the producers of the fertilization machines the most important recommendation that comes forth out of this research is to invest in the development of a machine which is able to apply the fertilizer site-specific. This site-specific application is expected to become a requisite ability in order to compete in the market of (liquid) fertilization machines.

Based on this research the dealers and traders active in the agricultural machinery (the fertilization suppliers) are advised to add the spoked-wheel fertilizer to their product-range, so that they can respond to the increasing demand for this machine. Besides the sale of spoked-wheel fertilizers it is wise to gain knowledge and understanding on the abilities and the maintenance of the spoked-wheel fertilizer, so that the service of the machinery-supplier on this machine becomes a continuous revenue stream.

The contractors are advised to invest in liquid fertilizer injection with special attention for the ability of (conversion to) site-specific application. Because the demand for liquid fertilizer injection will grow according to the respondents, the employment of the contractor will also grow.

The contractor has to 'sell' the fertilization method to the dairy farmer and therefore he or she must have sufficient knowledge of the machine and its abilities.

The most important recommendation for Dutch dairy farmers that can be provided based on this research is (in general): Invest in resource efficiency. The resource efficiency can be improved on several aspects within the Dutch dairy sector. Firstly, the mineral management is of vital importance given the current and future challenges described by this research. In order to perform the mineral management as efficient as possible several measures are currently applicable:

- Liquid fertilizer injection
- Timing of fertilization and harvesting
- Fertilizing according to demand instead of usage
- Manure processing to enlarge the efficiency
- Catch crops after harvesting the main crop (not for grassland)

Besides the abovementioned measures, this study has shown that the future is expected to bring more possible methods to increase the mineral efficiency:

- Site-specific demand-analysis and fertilization
- Manure processing into fertilizer
- Robot fertilization

In addition to increasing mineral efficiency there are other aspects on which the resource efficiency can be increased in the Dutch dairy sector. Based on this study the researcher thinks it is advisable for dairy farmers to; increase the average lifetime of their cows, construct their stables according to do the 'Maatlat Duurzame Veehouderij' (Yardstick Sustainable Livestock), monitor the health of their cows more individually and intensely, increase the labour-efficiency by for instance automating the 'simple' tasks such as feed pushing or by outsourcing the machinery-labour to a contractor. When the dairy farmer increases the resource efficiency, the profitability of his or her farm will increase as well.

6. Discussion

In this chapter the limitations of this research will be discussed. In addition to that recommendations for further research will be given.

6.1. Limitations

One of the limitations of this study lies in the validity of the generalizability, since the Delphi study was executed with 30 respondents and in the second round each subject was covered by one to eight respondents. Therefore the conclusions that are drawn regarding these subjects are based on a few experts and in some cases merely on individuals. Because of this the conclusions and insights that were stated in this research cannot be generalized without accounting for the statistical insignificance. Due to time constraints and to keep the willingness to participate amongst the respondents, the researcher aimed to address the respondents with the most expertise regarding the subject instead of discussing all subjects with all respondents, thereby a great deal of the validity of the results relies on the judgment of the researcher. In some cases conclusions were drawn based on one individual even when a group of other respondents thought differently, this is done because in this case the researcher expects the individual respondent to be the absolute expert based on background, profession, and/or provided insights. This makes the validity even more dependent on the judgment of the researcher.

2 of the respondents were not interviewed face-to-face, due to time constraints on both sides a face-to-face appointment could not be made, therefore these respondents answered the questions of the first round by phone. The researcher did not notice any less involvement or interaction during the interviews. However, it was harder to recognize the opinions of the interviewees because body language could not be taken into account.

A part of the data that was obtained during the first round has not been used in the research. The respondents were asked to estimate investment aspects for the fertilizer injectors and a granulate spreader, however most respondents stated that it was hard to estimate and only 9 respondents actually did estimate the investment aspects. Besides obtaining the general perception of the expensiveness, the researcher has decided not to do a financial analysis because of the lack of reliable information.

At first the second round was in place to rank the aspects that were mentioned during the first round. However, the method was adapted during the research because during the first round it became clear that this ranking would result in the most commonly known aspects being ranked the highest, but this does not provide the in-depth insights that was aimed for by this research. Therefore, the second round was changed into in-depth interviews with only a few subjects (maximum of 6 subjects per expert). As stated in the methodology, the panels have been assembled as heterogeneous as possible within this research. This is especially the case for the Dutch dairy chain panel. This was important to gain insights from all relevant angles in this chain, however, it also has a downside; it complicates the recognition of the expert that provides the most relevant insight on a certain development.

Due to the fact that only 2 rounds were held, the respondents that were interviewed at the beginning of the second round have had no chance to react on the responses of the interviewees that were interviewed after them. This might have caused relevant information or insights to be missed. Another downside of not having a third (or even fourth) round is that for a lot of challenges and solutions consensus or the reasons for not reaching consensus were not fully explored. This complicated the interpretation of the results.

5 of the 30 respondents did not participate during the second round, for 3 respondents this was because of holidays, the other 2 respondents could not participate due to time constraints. Unfortunately, 4 of these 5 were from the Dutch dairy chain expert panel which caused imbalance between the panels. The other respondent was contractor and belonged to the practitioner panel.

During this research significant developments occurred in the Dutch dairy chain. In the designing phase the dairy sector stood on the verge of the quota-free era, this however did not last long. On the second of July this year phosphate rights were announced, right before the start of the second round of the Delphi. Where in the first round several restrictions were mentioned by the experts (phosphate rights being one of them), the second round incorporated the consequences of the phosphate rights. Nonetheless, the exact design of the phosphate rights was not known during the second round and therefore some consequences might have been missed.

6.2. Recommendations for further research

During this research several ideas for further research emerged. First of all, a policy Delphi as described by Turoff would be a method which would provide more insight in the pros and cons for certain choices regarding smart fertilization and the motivation behind those choices. With this setup of a policy Delphi the respondents are forced to choose and thereby the arguments for or against certain methods will become clear. This Delphi method takes four to five rounds and was therefore not applicable in this study, however, with this study as starting point it could provide an interesting further research.

Several developments in the Dutch dairy chain that were recognized by this research are interesting and complex enough to be research topics on their own. The following potential solutions for the challenges that are faced by the Dutch dairy farmers are recommended for further research by the author:

- Manure refinery in order to use it as fertilizer
- Site-specific fertilization (-sensors)
- Robot fertilization
- Farm-specific manure and fertilizer legislation
- Greenhouse gas reduction methods
- Alternative medicines for (bovine) antibiotics

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Appendices

Annex 1: Dutch dairy chain

In this chapter the Dutch dairy chain will be described. It will address the dairy farm itself as focal company. The scope of the chain that will be described is from the Tier 1 suppliers to the end-consumer. The Tier 2 suppliers are not described since this tier is too large to cover in the given timeframe. Figure 11 is extracted from a study of Lambert and Cooper and is displayed below in order to clarify this scope, the black rectangle represents the scope (2000). The description of the Dutch dairy chain includes the businesses that are present in this chain and what these businesses bring to the chain, i.e. what they sell or provide. In addition to that a schematic overview will be provided.

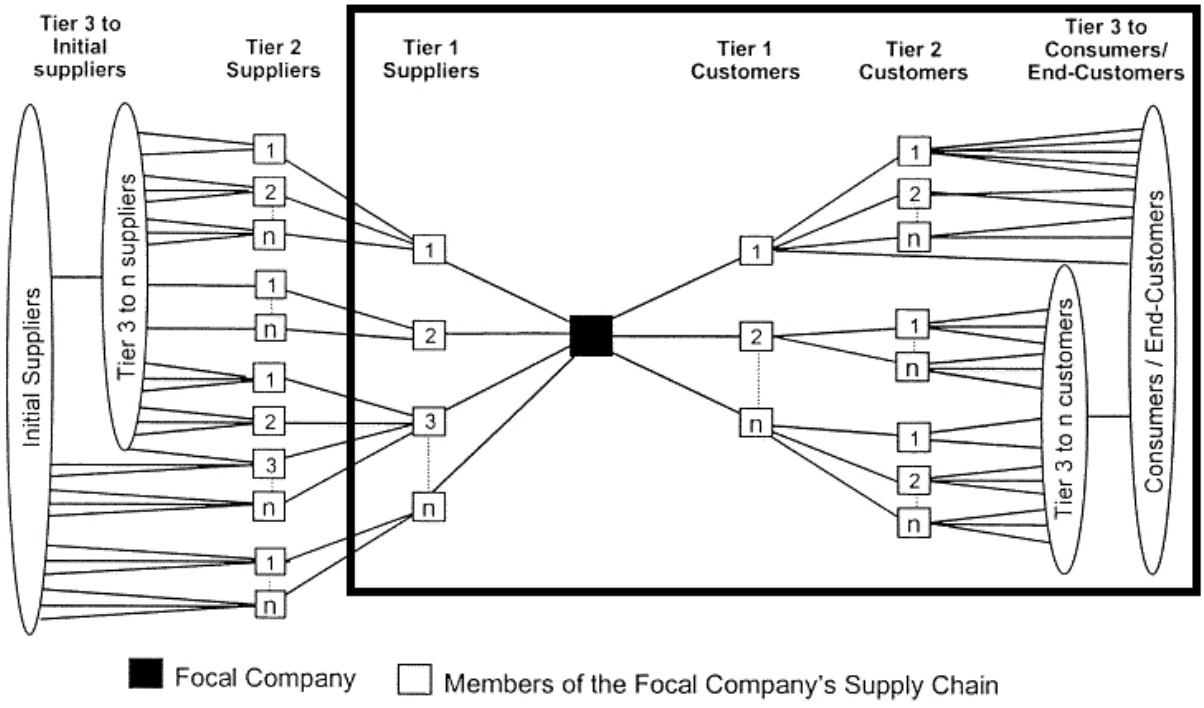

Figure 20: Supply chain (Lambert & Cooper, 2000) adapted with rectangle indicating the scope of the Dutch dairy chain

1.1 Type of supply chain members

Lambert and Cooper distinguish two kinds of supply chain members; primary members and supporting members. They define primary members of the supply chain as; '*all those autonomous companies or strategic business units who carry out value-adding activities (operational and/or managerial) in the business processes designed to produce a specific output for a particular customer or market*' (2000).

For the Dutch dairy chain the primary members, when the definition of Lambert and Cooper is applied, are; the dairy farm itself, the milk-processor, the industrial user, the professional user and the retailer. The dairy farm is the focal company, the milk-processor is a tier 1 customer and the industrial user, the professional user and the retailer are tier 2 customers. The retailer is also a tier 3 customer when the products they sell come via an industrial user. The retailer and the professional user, such as bars and restaurants, sell the products to the end-customer (FrieslandCampina, 2012).

The supporting members are defined as; '*companies that simply provide resources, knowledge, utilities, or assets for the primary members of the supply chain'* (Lambert & Cooper, 2000). This, of course, includes much more companies than the primary members.

1.2 Tier 1 suppliers

The tier 1 suppliers are the direct suppliers of the focal company, in this case the dairy farm. These suppliers are subdivided based on what they supply to the dairy farm, this subdivision is executed into the following categories:

- Resources
- Knowledge
- Assets
- Services

All tier 1 suppliers will be mentioned at the corresponding category.

Resources
One of the resources that is delivered to the farm is feed which is not produced by the farmer. This feed is delivered by a feed mill. A feed mill buys raw materials and sells them as they are or process them into pallets before the sale to the dairy farmer (Veldhuizen, 1996). Another resource is fertilizer, this is often also delivered by the feed mill but there are also companies that are specialized in fertilizer (Triferto, 2015) . The process is likewise, raw materials are bought and processed into the ready-to-use form. The financing of investments done by the dairy farm can come from savings and external financial resources. These external financial resources are in most cases supplied by the bank in the form of loans (Biewenga, et al., 2009). Antibiotics and other medicines that require a prescription are bought from the veterinarian (Remmelink, et al., 2014). Medicines without prescription and other health-care products can be bought at wholesalers in agricultural products. These wholesalers are suppliers of many more products like chemicals, tools, silage-pit requisites etcetera (MS Schippers, 2015). Another resource is dairy-bull semen which is used for artificial insemination, this provides accretion of the herd and causes cows to give milk. The semen is delivered by herd improvement companies. These companies have breeding programs in order to select and breed the best bulls and extract their semen in order to sell this to the dairy farmer (Biewenga, et al., 2009). Another resource that is required by the dairy farm is fuel in order to operate the machinery. Fuel is delivered by the (local) fuel supplier, this fuel supplier bought the fuel from the oil-distribution centre where the oil is being distributed after being refined at a oil-refinery (Petrol Prices, 2015). Gas, water and electricity are resources that are delivered by the utilities (Nuon, 2015).

To give a quick overview of the companies involved in supplying resources to the dairy farms, the following list is formulated:

- Feed Mills
- Fertilizer specialists
- Banks
- Veterinarian
- Agricultural wholesalers
- Breeding companies
- Fuel suppliers
- Utilities

Knowledge

Consultancy in a particular field of expertise is often done by a representative of a company that delivers resources to the dairy farm. This applies for the feed mills, fertilizer specialists, banks, veterinarian and the breeding companies (Biewenga, et al., 2009). In addition to that there is the accountant that consults on financial, strategic, fiscal, legal, labor and subsidy issues (Flynth, 2015). There are also independent consultants in the dairy chain, these offer a wide range of expertise and do not have to sell any other products but their advice (DLV, 2015). Besides consultancy there are other ways of transferring knowledge to the dairy farms. Several research institutes are active in the field of dairy (Biewenga, et al., 2009). Another way of transferring knowledge are the journals and websites with sector specific news and developments. Finally, the Dutch and European government are also involved in knowledge transfer towards the dairy farms. They provide knowledge regarding the legislation. the subsidies and funds that are granted, latest developments, future vision for the sector, frameworks and guidelines (European Commision, 2015) (Rijksoverheid, 2015).

The actors providing knowledge for dairy farmers are:

- Feed Mills
- Fertilizer specialists
- Banks
- Veterinarian
- Breeding companies
- Accountants
- Independent consultants
- Research institutes
- Journals (websites)
- Governments

Assets

Real estate agencies deal in several forms of assets, they sell land, residences, buildings such as stables, storage pits and barns. In addition to that they also set-up lease agreements between the landlord and the tenant (Funda Landelijk, 2015) (Methorst, 2010). Farmers also sell and buy these assets directly to each other. Constructing buildings is also creating assets. Therefore, the constructors belong to this category as well. There are a lot of construction companies that are specialized or have a specialized department for agricultural constructing (Fekken, 2015). Another form of assets are the several types of equipment, for instance the milking parlour, feeding station and manure-scraper. This equipment is bought from dealers, traders and from other farmers directly (Lely, 2015) (Agriplaats, 2015). For machinery the same is applicable, it is sold by dealers, traders and farmers (Klein-Hesselink, 2015). According to Barry and Ellinger breeding livestock is also a form of assets at dairy farms (Barry & Ellinger, 2012). Breeding livestock is grown at the dairy farm itself, at another dairy farm or by an young stock breeder. Dairy farmers can buy breeding livestock from livestock-traders and other farmers (Koemarkt, 2015).

Assets are provided by the following type of companies:

- Real estate agencies
- Constructors
- Dealers (equipment and machinery)
- Traders (equipment, machinery and livestock)
- Farmers (real estate, equipment, machinery and livestock)

Services

A service that is provided to dairy farms is labor, labor is provided by employment agencies or directly by the employee. An example of an employment agency is AB Oost, a company that is specialized in the field of agriculture (AB Oost, 2015). Another type of service are the management programs, these are provided by companies that are specialized on this field, but also by breeding companies and feed mills. The management programs provide a wide range of indicators on the herd which enable close monitoring and managing by the farmer (CRV, 2015). Breeding companies also deliver several other services, such as artificial insemination, animal registration and assess cow-exterior (Biewenga, et al., 2009). A service regarding manure management; how much, when and where manure should be spread, is provided based on soil samples taken by the dairy farmer or an employee of the company providing this service (BLGG, 2015). Dairy farmers who want to outsource the arable work (partially) can hire contractors to do this for them (Huiskamp, 2015). The veterinarian also provides services such as developing the farm treatment plan, gestation monitoring, first aid, diagnose diseases and counselling (Vee & Arts, 2015). Milk recording is a service which enables the dairy farmer to monitor the milk yield, -composition and somatic cell count per cow. The farmer can use these indicators for the herd management. Milk recording is mostly done by specialized companies, but it can also be done in house. If the latter is the case, the samples have to be shipped to the laboratory where the milk will be examined (Biewenga, et al., 2009). The silage that is harvested by the dairy farmers is often assessed by silage samplers, they take samples and provide overviews of the nutritional value of the specific silage pit to enable the dairy farmer to feed a ration that meets the requirements of the herd (Biewenga, et al., 2009). When machinery is broken and it is beyond the capabilities of the farmer to fix it, it is taken to the machinery dealer where mechanics are employed, or the mechanic comes to the farm in order to fix the machinery at location (Klein-Hesselink, 2015). When equipment such as the milking parlour is broken a service mechanic from the dealer will come to the farm to fix the problem (Kuiper, 2015). When a dairy farm generates more manure than it can legally place on the land, it has a operating surplus. This surplus of manure has to be processed (partially), this can be done by manure-processors on the farm or the farmer can buy a replacing processing agreement, in the latter case the manure will be processed elsewhere (Verkerk, 2013).

Services are provided to dairy farms by the following actors in the chain:

- Employment agencies
- Employees
- Management program providers
- Breeding companies
- Feed Mills
- Soil samplers
- Contractors
- Veterinarian
- Milk samplers
- Silage samplers
- Dealers (machinery and equipment)
- Manure processors

1.3 Tier 1 customers

Where a dairy farm has many suppliers, only a few customers can be recognized. The aforementioned primary supply chain member the milk processor is one of them. The end-customers of the dairy products also buy directly at the farm. This can be the case for raw milk, but it can also be that the dairy farmer processes (a part) of the milk that is produced at the farm. Products like cheese, yoghurt and ice cream are in addition to raw milk products that are commonly sold in farm-shops (Captein, 2015) ('t Dommerholt, 2015). Meat is also sold at farm-shops, the animals go to the butcher to get slaughtered, after that the meat is placed in the farm-shop to be sold to the end-customers (Vijn & Van Boxtel, 2014). Cattle that is sold by dairy farmers can be bought by several customers. One of these are other dairy farmers. When a dairy farmer purchases cows or calves directly from another dairy farmer it is bought for milk-production purposes. Veal farmers also buy calves from dairy farmers with the purpose of meat-production. Butchers buy livestock directly from dairy farmers for slaughter. An intermediate between dairy farmers and the aforementioned livestock purchasers is the livestock trader, livestock traders buy livestock from dairy farmers in order to resell it (Koemarkt, 2015). Milk is seen as the core product of the dairy farms, all other products are seen as by-products, the chain of these by-products will be elaborated on in the section '4.6 By-products supply chain' of this chapter.

Tier 1 customers are:

- Milk processor
- End-customers
- Butchers
- Dairy farmers
- Veal farmers
- Livestock traders

1.4 Tier 2 customers

The tier 2 customers described in this section are the customers of the milk processors, the other tier 2 customers are described in the section on by-products. There are three types of customers distinguished; retailers, industrial users and professional users. The retailers, for example super markets, sell ready-to-consume products which are supplied by the milk processor. The industrial users buy ingredients from the milk processor in order to produce their own product. The professional users, for example restaurants, use the products from the milk processor to prepare meals and other consumables for their customers (FrieslandCampina, 2012).

Tier 2 customers of the primary chain are:

- Retailers
- Professional users
- Industrial users

1.5 Tier 3 Customers

The tier 2 retailers and professional users are the last link in the chain before the products reach the end-customer. The industrial users however, sell their product to the retailers and professional users (FrieslandCampina, 2012). Therefore, the retailers and professional users are also tier 3 customers.

Tier 3 customers:

- End-customers
- Retailers
- Professional users

Tier 4 customers:

- End-customers

1.6 By-products supply chain

As determined above, dairy farms generate several by-products. One of these products are calves that are male or not wanted by the farmer for accretion of the herd. These calves can be sold to other dairy farmers, but in most cases these calves end up at veal farms (Productschap Vee, Vlees en Eieren, 2015). The supply chain of veal is schematically shown in Figure 12 below.

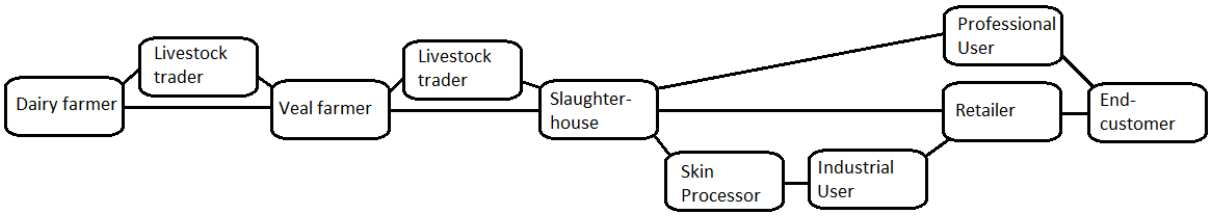

Figure 21: Veal supply chain (Van Drie Group, 2012)

As the supply chain shows, the dairy and veal farmer can sell the calves directly towards the next processing link in the chain, however, the livestock trader can be an intermediary step. The outputs of the slaughterhouse are veal and calfskins, the veal is transported to the retailers and the professional users such as restaurants. When the calfskins are processed they are sold to industrial users, where the leather is used in the production of for example shoes, clothes, furniture and cars.

Another by-product of dairy are the cows that are (no longer) needed or suitable for milk production. The same is applicable as for calves; the cows can be bought by dairy farmers (especially the relatively young cows), but the major share is being culled and brought to the slaughterhouse (Stoop, 2015). A schematic overview of this supply chain is shown in Figure 13 below.

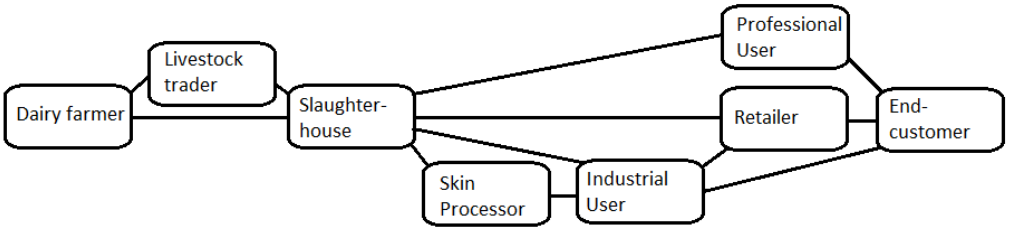

Figure 22: Culled cows supply chain

This supply chain is very similar to the veal supply chain. The culled cows are brought to the slaughterhouse directly or via a livestock trader. The meat of the cows is sold to professional users and retailers. The skin is processed in order to be utilized in the different industries. A cow has many more products that are utilized in several industries, this is represented by the direct link between the slaughterhouse and the industrial users. The industrial users are producers of

various types of products like household goods, pharmaceuticals, travel-related products and clothing. 99 percent of a dairy cow is utilized thanks to the many purposes found in the different products (Dairy Max, 2015). These products are sold to the end-customer directly or via the retailer link in the chain.

1.7 Dutch dairy chain overview

The schematic overview of the Dutch dairy chain is shown below in Figure 14. The chains of the 'by-products' are also integrated in this schematic overview. From the dairy farm there are 3 chains distinguished. The top chain is the chain where the male and unwanted calves eventually reach the end-customer as veal and leather products. The middle chain is the primary chain; the dairy products chain. The bottom chain is the chain where culled cows reach the end-customer in the form of the numerous products that can be produced out of cows.

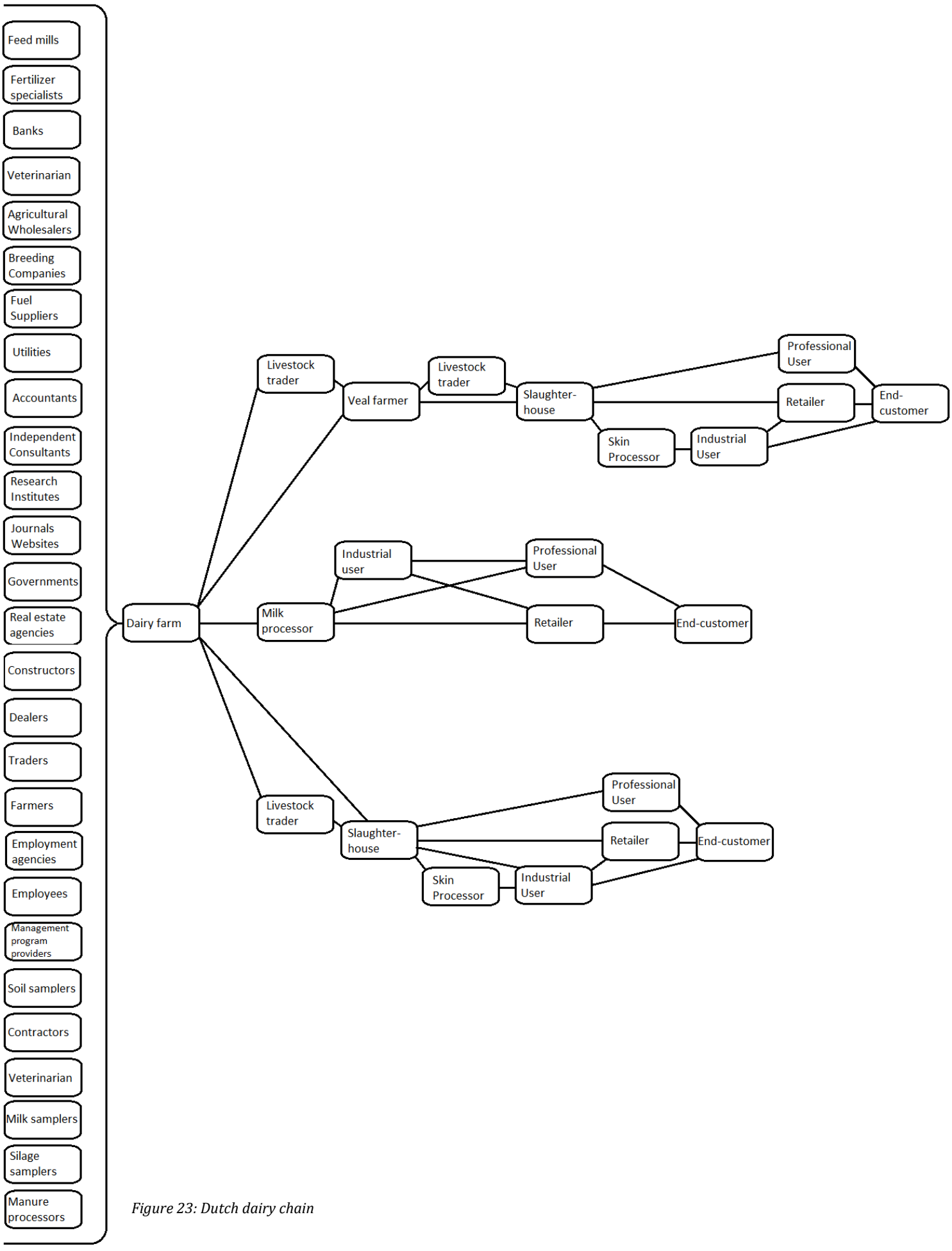

Figure 23: Dutch dairy chain

Annex 2: The Delphi method

In order to acquire a good vision on the feasibility, impact and risk of an innovation without actually possessing all the facts of the innovation, experts have to assess the innovation from the different angles of their expertise. In this way an estimation of all the information that is needed for the analysis, and that is not known yet, can be made. The people who already worked with a prototype or even the final product can be addressed, but also the potential users of the innovation, the Dutch dairy farmers, can give their opinion on the potential of the innovation. These 'experts' can be divided into two groups. The people that already worked with the product or a prototype of it analyse the product in retrospective whereas the people who might work with the product in the future perform a use-analysis in prospective (Nelson, et al., 2013).

To analyse the feasibility, impact and risk of the innovations, experts from different fields and backgrounds have to analyse the innovation and provide a judgement. An overall conclusion on the potential of the innovations is necessary and for that reason the Delphi method is applicable for this research. In a study after the the current validity of the Delphi method Landeta states: *´The Delphi method is a popular technique for forecasting and an aid in decision-making based on the opinions of experts, which has been in existence for over half a century'.* In this study he concludes that the Delphi method still is a valid instrument for forecasting and supporting decision-making (Landeta, 2006). The Delphi method aims at obtaining and defining a group judgement. Often experts come with different conclusions when asked to analyse the same subject, especially when these experts have different backgrounds. The Delphi method is a research method that aims at gaining consensus regarding the subject between the participating experts (Okoli & Pawlowski, 2004). This consensus is reached by several rounds of interviews with the same experts. However, Turoff has described another purpose of the Delphi study for cases were consensus simply will not be achieved due to the strongly different viewpoints. In his study he describes the design of a 'policy Delphi' opposed to the common Delphi also known as the 'technological Delphi', the goal of this Delphi method differs: *"Its goal in this function is not so much to obtain a consensus as it is to establish all the differing positions advocated and the principal pro and con arguments for those positions."* (Turoff, 1970). According to Dalkey, the founder of the Delphi method in the 1950's, there are 3 important features that are characteristic for the Delphi method:

- Anonymous response
- Controlled feedback
- Statistical group response

All experts remain anonymous throughout the process, the opinions are gathered via a formal questionnaire. Between all rounds the results of the previous round is summarized and communicated back to all participants, this reduces *noise.* When the questions involve estimations of numbers, the statistical group response is a convenient instrument to take into account all the answers. In this way all experts feel appreciated, and ,maybe even more importantly, further analysis becomes more accurate (Dalkey, 1969). This increase in accuracy is endorsed by Landeta: '*The average consensus in the second round was greater than in the first. The average typical deviation of the different distributions from the first round was 3.35, while it was 2.43 in the second round*' (2006). A critique on the Delphi method of course is that it does not rely of factual information but on intuitive insights and therefore it is not as reliable as concrete measurements (Pill, 1971). On the other hand, waiting until concrete measurements can be obtained is not always an option, as is the case in this research. A strength and at the same time a weakness of the method lies in the group judgement, Pill clarifies this as follows: 'I*t is undoubtedly true that a group has more total expertise than any of its members, but it also dilutes the opinion of the real expert on the*

particular question that is being considered' (1971). A point of critique pointed out by Rowe and Wright is the lack of specific instructions on the role of feedback. In their study is mentioned that the Delphi method requires more structured guidelines to be used to its full potential (1999). The Delphi method can be used for qualitative, quantitative and mixed research models according to Skulmoski et al. In the same study the authors warn for the use of heterogeneous samples since these can greatly increase the complexity of the results. This will also cause it to be much harder to reach consensus amongst the panel (2007). Turoff however states that the respondent group should be as heterogeneous as possible, because: *"The use of a heterogeneous group is the best way to stimulate a systematic exploration of all the pros and cons on specific resolutions"* (1970). In several studies it is stressed to bear in mind that if a researcher chooses to use the Delphi method a great deal of the responsibility for success of this method lies with the researcher and the execution of the Delphi method (Rowe & Wright, 1999) (Skulmoski, et al., 2007) (Okoli & Pawlowski, 2004).

The Delphi method relies on the intuitive judgment of experts on the topic that is addressed by the researcher. Therefore, a well-structured procedure for soliciting these experts is in place. The study of Okoli and Pawlowski applies the method designed by Delbecq et al. (1975). This method exists out of a Knowledge Resource Nomination Worksheet (KRNW). This worksheet helps categorizing experts before identifying them by looking for the relevant organizations, disciplines and literature that will hold the experts on the subject (Okoli & Pawlowski, 2004). An example of an KRNW for an IT-study is shown below:

Disciplines or skills	Organizations	Related literature

• Academic
  ○ Journals list
• Practitioner
  ○ Internet Societies
  ○ ITU sector members and associates
• Government official
  ○ ITU Global Directory
• NGO official
  ○ Organizations list
	• World Bank
	• United Nations Economic Commission for Africa
	• United Nations University
	• Internet Societies in Africa
	• African governmental ministries of telecommunications
	• AFRIK-IT listserv
		Academic:
		• Review of African Political Economy
		• Journal of Management Information Systems
		• European Journal of Information Systems
		• Journal of Global Information Management
		• Journal of Global Information Technology Management
		• Electronic Journal of Information Systems in Developing Countries
		
		Practitioner:
		• Communications of the ACM
		• Africa Business
		• Proceedings of ITU Telecom

Figure 24: IT Sample KRNW (Okoli & Pawlowski, 2004)

In the KRNW that is shown above a clear distinction in categories is made between academics, practitioners, government and NGO's. Eventually an expert-panel from each category will be participating in the Delphi-study. The process shown below is coherent with the KRNW above.

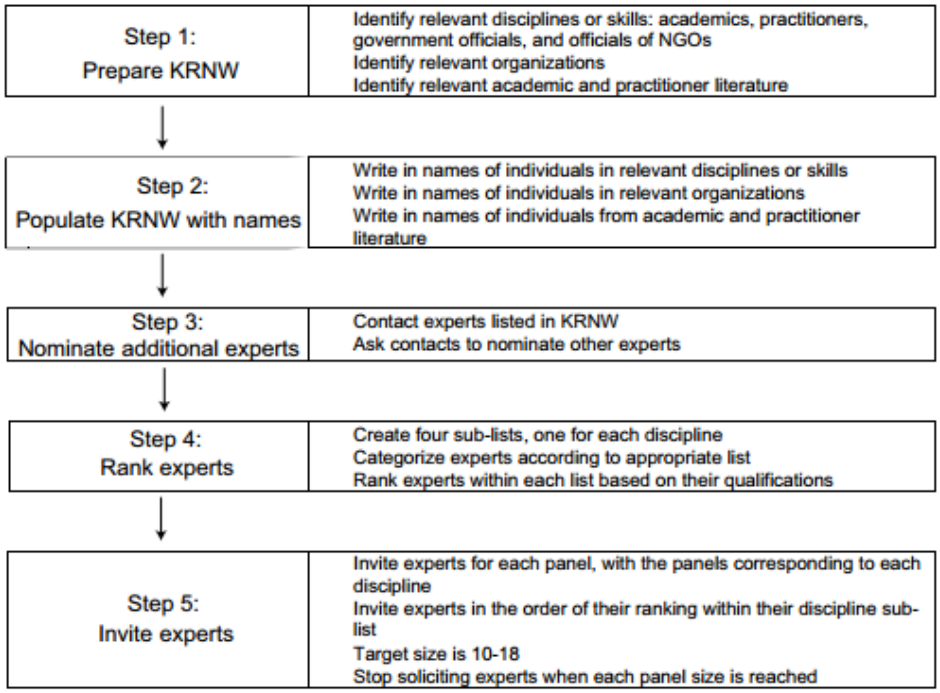

Figure 25: Panel creation process (Okoli & Pawlowski, 2004)

The process is applicable for any Delphi study and gives a clear structure for selecting and soliciting the experts for the different panels that are required for the study. Therefore, this process will be applied for this thesis in order to compose relevant and knowledgeable panels. When all experts are solicited and in place to start with the process, the start of the first phase shown in the following figure can take place. The process that is shown below is specifically designed for the study of Okoli and Pawlowski, based on the method described by Schmidt et al. but the major part is directly applicable for other Delphi studies (Schmidt, et al., 2001) (Okoli & Pawlowski, 2004).

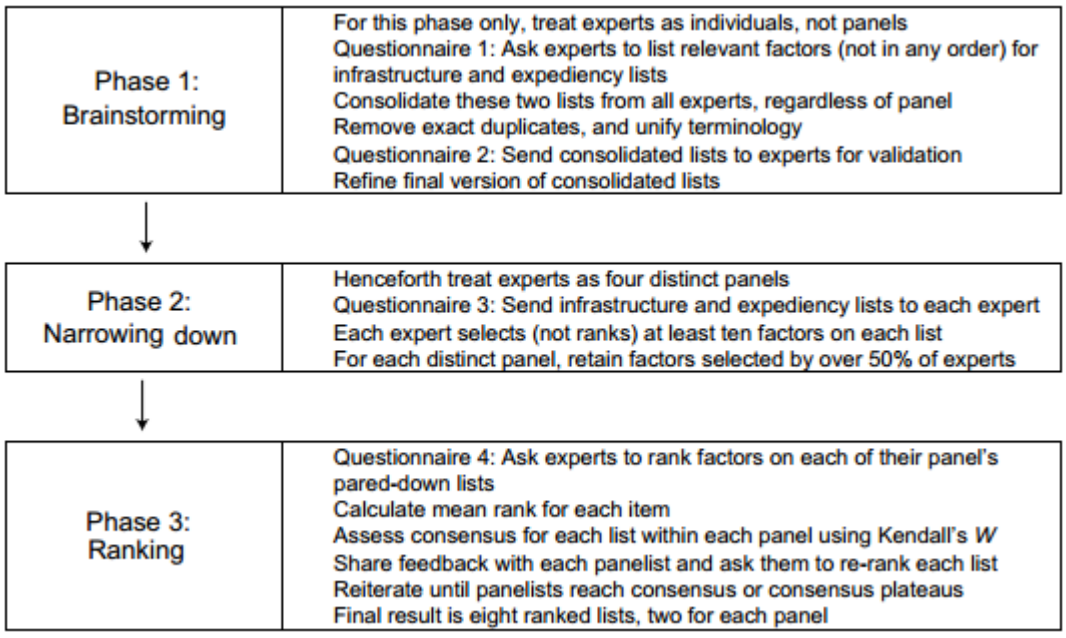

Figure 26: Delphi method process (Schmidt, et al., 2001) cited by (Okoli & Pawlowski, 2004)

In the example above three phases are described. During the first phase all relevant factors are gathered by two questionnaires, the first one to come up with the factors and the second one to verify the results and interpretation of the researcher. During the second phase the experts are treated as panels from which the 50% most mentioned factors will be retained. In the final phase the factors will be ranked per panel by each expert individually. When all this information is gathered the researcher starts with the analysis of the results of the Delphi process.

A comparison between the traditional survey method and a Delphi study was made by Okoli and Pawlowski (2004). They compared the methods on 10 criteria drawing the following conclusions, a summary of this comparison is formulated below:

Procedure

The design issues of a survey apply for both of the methods, however, the Delphi method involves designing multiple surveys for the same respondents. Another difference is the feedback and coming to a final consensus amongst each panel. These panels are also a major difference, where the traditional method always is answered individually the Delphi method aims the questions at specifically designed panels that are knowledgeable on the regarding subject.

Sample representativeness

The traditional method uses statistical sampling techniques that provide the number of required respondents to define the sample as representative for the population. This is in great contrast with the Delphi method which investigates the questions with high uncertainty and speculation. Therefore the traditional method is not applicable since there are not enough experts on the subject.

Sample size and significant findings

The traditional method aims at generalizing the results to a larger population, the number of respondents required can be calculated. The group-size for a Delphi method does not use statistical power to calculate the ideal group-size. According to the literature a group-size of about ten to eighteen experts is recommended for each panel.

Individual vs. group response

The traditional survey method is always an individual approach. Whereas the Delphi method eventually requires consensus from a group of experts which is superior to individual response of experts when expert-judgement is required. Therefore, the suitability of the method depends on the purpose and type of the research questions.

Construct validity

For both methods pre-testing and careful designing is applicable. For the Delphi method construct validity can also be checked by asking experts to evaluate the interpretation of the researcher.

Anonymity

With the traditional survey method respondents are always anonymous to each other and in many cases also anonymous to the researcher. For the Delphi method anonymity is only between respondents. The researcher always knows who the respondents are. An advantage of knowing the respondents is the ability to clarify answers.

Non-response issues

For the traditional method non-response bias always has to be investigated to ensure representativeness of the sample. The non-response rate for the Delphi method is typically very

low because the experts already pledged their participation. Besides, the experts are often interested in the opinions of their colleagues and the outcome of the study.

Attrition effects

For single surveys attrition, of course, is a non-issue. With repeated surveys, attrition effects need to investigated to ensure it is unbiased. For the Delphi-method the attrition-rate is again low. In case of attrition the researcher can easily find the cause of the drop-out by talking to them personally.

Richness of data

For both methods the depth and form of the questions have great influence on the richness of data. Follow-up might add to the richness of data, but for the traditional survey method this is often difficult because of the anonymity towards the researcher. Delphi studies typically provide richer data compared to the traditional method because of the multiple rounds, iterations and feedback.

This comparison by Okoli and Pawlowski endorses the relevance of the Delphi method for this specific study, because of the high uncertainty, speculation, limited knowledgeable people, type of subjects and type of research questions (2004).

Annex 3: Knowledge Resource Nomination Worksheet

As described in the methodology, the KRNW helps setting up the panels for a Delphi-study. For this thesis the initial KRNW is displayed in the table below.

Table 1 KRNW

Disciplines or skills	**Organizations**	**Related literature**
Dairy farmer	Dairy farms	Financial Management in Agriculture
Dutch dairy chain experts	The companies of the regarding innovation	Exploring Innovation
Smart fertilization experts	Wageningen UR	Fundamentals of Strategy
Contractor	LTO	Melkvee
	CAH Vilentum Dronten	International Journal of Innovation Management
	Flynth	Journal of Technology Management and Innovation
	Countus	Technological Forecasting and Social Change
	Rabobank	Handboek Melkveehouderij
	ABN-AMRO	KWIN Veehouderij
	Agruniek-Rijnvallei	Nieuwe Oogst
	Agrifirm	BoerenBusiness
	FVNL	Boerderij
	Van Hall Larenstein	
	Nederlandse Zuivelorganisatie	
	ZuivelNL	
	FrieslandCampina	
	Contractors	
	Kverneland	
	LEI	
	HAS Den Bosch	
	NZO	
	Courage	
	Cumela	
	BLGG	
	Van Iperen	
	Agrimedia	
	Duport	
	Güstrower	
	Gromes Plender	
	Triferto	
	Louis Nagel	
	PPL	
	NMI-Agro	

Annex 4: Expert panels

The experts are coded as follows: (1=SF, 2=contractor, 3=dairy farmer, 4=Ddc, 5=subject expert)

Code	Profession	Type of company
1A	Managing director	Information/education smart fertilization
1B	Scientist soil-, nutrient, and crop-management	Research institute
1C	Knowledge developer on forage and fertilization	Feed/fertilizer supplier
1D	Scientist soil-, nutrient, and crop-management	Research institute
1E	Scientist agrosystems	Research institute
1F	Product manager	Machinery developer/producer
1G	Senior projectmanager	Knowledge institute nutrients
1H	Scientist agrosystems, cropmanagement	Research institute
1I	Editor in chief	Branch literature
1J	Secretary fertilizer-distribution	Agricultural NGO
2A	Contractor	Contracting
2B	Contractor	Contracting
2C	Contractor	Contracting
2D	Contractor	Contracting
2E	Contractor	Contracting
3A	Dairy farmer	Dairy farm
3B	Dairy farmer	Dairy farm
3C	Dairy farmer	Dairy farm
3D	Dairy farmer	Dairy farm
3E	Dairy farmer	Dairy farm
4A	Scientist dairy	Research institute
4B	Lecturer dairy	Agricultural Higher Professional Education
4C	Lecturer dairy	Agricultural Middle Professional Education
4D	Lecturer dairy	Agricultural Middle Professional Education
4E	Dairy specialist	Accounting
4F	Dairy nutrition consultant	Feed/fertilizer supplier
4G	Lecturer dairy	Agricultural Higher Professional Education
4H	Scientist system innovations agriculture	Research institute
4I	Open innovation director	Dairy processor
4J	Scientist livestock, project leader	Research institute/dairy development project
5A	Machinery developer	Machinery development
5B	Biochemist	Medicin production/development

Annex 5: Delphi Questionnaire Round 1

Round 1 Smart Fertilization

The goal of this research is mapping the potential and the impact of the disc injection fertilizer and the spoked-wheel fertilizer on the Dutch dairy chain. This first questionnaire will be held orally by Bart Gieling. The introduction of the innovations will be send in advance so the interviewee can prepare him-/herself for the questionnaire.

Participant:

- Name
- Profession
- Age
- Company
- Knowledge level on:
    - Dutch dairy chain Expert/High/Average/Below Average/None
    - Smart Fertilization Expert/High/Average/Below Average/None

For all listings, please try to mention as much points/aspects as possible to provide a complete picture of the potential of the innovation at issue. When Lowest-Probably-Highest are asked for, the following is meant; for probably you fill in your estimation, for lowest and highest you give the values of which you are certain the true value is in between.

Questions for Smart Fertilization

1.	What would you estimate to be the percentage of *dairy farmers* that will **apply** Smart Fertilization (in general) for fertilizing their fields?			What would you estimate to be the percentage of 'spoked-wheel fertilizer' of all Smart Fertilizers that will be applied?			What would you estimate to be the percentage of 'disc injection fertilizer' of all Smart Fertilizers that will be applied?		
	Lowest	Probably	Highest	Lowest	Probably	Highest	Lowest	Probably	Highest
Currently									
2017									
2020									
2025									

2. What would you estimate to be the percentage of dairy farmers outsourcing smart fertilization compared to the total of dairy farmers applying smart fertilization (outsourcing + DIY)?

3.	What would you estimate to be the percentage of liquid fertilizer that is used compared to the total amount of fertilizer?		
	Lowest estimate	Most probable estimate	Highest estimate
Currently			
2017			
2020			
2025			

4. How many hectares of grassland would you estimate a dairy farmer uses on average? (average total hectare is 49)

5. How many hectares of grassland would you estimate a contractor with a Smart Fertilizer fertilizes on average annually?

6. What might be limitations for the use of the fertilizer equipment and how can these limitations be overcome?		
	Spoked-Wheel fertilizer	Disc Injection fertilizer
What are potential limitations		
How to overcome these limitations		

7. What are or might become substitutes for the fertilizer equipment and what might become substitutes in general for improving soil fertilitiy?			
	Spoked-Wheel fertilizer	Disc Injection fertilizer	In general
Substitutes currently			
Substitutes in 2025			

8. What are the strengths, weaknesses, opportunities and threats for the fertilizer equipment?		
	Spoked-Wheel fertilizer	Disc Injection fertilizer
Strong aspects		
Weak aspects		
Opportunities (legislation, environmental demands, landbased farming)		
Threats (legislative restrictions, better technologies, nature conservation)		

9. Please fill in your estimation of the following investment aspects of the fertilizer equipment at issue										
		Spoked-Wheel fertilizer 12m, without tank			Disc Injection fertilizer 12m, without tank			Traditional fertilizer (centrifugal granular spreader)		
		Lowest	Probably	Highest	Lowest	Probably	Highest	Lowest	Probably	Highest
Price of the fertilizer (total investment)										
Lifespan										
Salvage value										
Extra annual revenues/ha compared to traditional fertilizer (for a dairy farmer)								N/A	N/A	N/A
Price per hectare of fertilizing by contractor										
Annual maintenance costs per hectare	Dairy farmer									
	Contractor									
Annual operational costs per hectare (labour, diesel)	Dairy farmer									
	Contractor									

10. What is in your opinion the best fertilizer and the best equipment for fertilizing now and in the future?		
	Best fertilizer equipment	Best fertilizer (manure, artificial fertilizer, and other fertilizers)
Now		
2017		
2020		
2025		

11. Business model aspects of producers and users of the fertilizer equipment		
	Spoked-Wheel fertilizer	Disc Injection fertilizer
Who are potential buyers (besides contractors and dairy farmers)?		
Who would be the key partners of the producer/seller of the fertilizer?		
Who would be the key partners of the user of the fertilizer?		
What resources would be needed to produce the fertilizer?		
What resources would be needed to use the fertilizer?		
What types of liquid fertilizer would be used with the fertilizer?		
What types of maintenance costs will be made using the fertilizers?		
What types of operational costs will be made using the fertilizers?		
What will be the major costs for producing the fertilizers?		
What aspects of the fertilizers would influence the financial result of dairy farmers positively?		
What aspects of the fertilizers would influence the financial result of dairy farmers negatively?		
Would there be revenue streams for the producer other than just selling the fertilizer?		
Via what (marketing and distribution) channels could the fertilizer be sold? (direct, via dealer, via agent and dealer)		
What customer relationships are to be expected between the seller of the fertilizer and the user? (service, consultancy etc.)		

General questions

12. What developments do you expect on the short and on the long term in the Dutch dairy chain? Please give your vision on the following aspects:	
Environment (for example; changing legislation, less emission, less pollution)	
Sustainability (for example; re-using waste-streams, alternative utility sources)	

13. Do you have any comments, questions or advice on the introduction, this questionnaire or one question in particular?

Annex 6: Results 2nd Round

For the Excel-version please contact the author.

Vloeibare kunstmest injectie groeit naar meer dan 40% bij melkveehouders in 2025 (is de gemiddelde verwachting blijkt uit de eerste ronde)

Waarom groeit dit?	1C	1F	3A	1E	1D	1A
Toename gebruik van reststromen	x		x	x	o	X
Behoefte aan precieze plaatsing	x	x				X
Behoefte aan mineralenefficiëntie (kosten, fosfaatrechten, kringloopwijzer, andere milieu-eisen,	x	x	x	x	x	X
Plaatsspecifieke bemesting wordt mogelijk						x
Waarom groeit dit niet harder?	1C	1F	3A	1E	1D	1A
Logisitiek van vloeibare meststoffen	x		o	o	x	x
Langzame ontwikkelingen van technieken	x					
Sterke lobby korrelkunstmestindustrie		x	o		x	x
Dure methodes			x	x	x	x
Niet aangetoond betere mineralenbenutting			x	x	x	

Plaatsspecifieke bemesting

Wat zijn de voordelen?	1C	2B	2E	2C	1E	4F
zoveel mogelijk rendement uit meststoffen	x	x	x	x	x	x
mineralenefficiëntie wordt beloond	x					
Welke stappen moeten nog genomen worden?	1C	2B	2E	2C	1E	4F
sensoren om bodembehoefte plaatsspecifiek te analyseren	x	x			x	
vertaalslag tussen analysedata en daadwerkelijke behoefte	x			x	x	
sensoren voor real-time analyse van behoefte van bodem en gewas moeten worden ontwikkeld			x			x

machines die plaatsspecifiek kunnen bemesten moeten goedkoper worden					x						
Wanneer is dit in de praktijk?	1C	2B	2E	2C	1E	4F					
Over 5 jaar zijn de eerste machines in de praktijk voor grasland	x	x	x		x	x					
in 2017 zullen de eerste machines voor grasland in de praktijk zijn				x							
Hoeveel % van de meststoffen kan dit besparen?	1C	2B	2E	2C	1E	4F					
Niet te zeggen omdat variatie in bodem nog onbekend is	x										
20-30% besparing mogelijk met precisie op het niveau van 10M2					x						
Er zal niet bespaard worden, de opbrengst wordt verhoogd				x		x					
Hoge druk injectie											
Wat zijn de voordelen?							5A	1B	1H	1A	
Plaatsspecifieke toediening							x			x	
grotere capacitieit en lichter t.o.v. spaakwielbemester							x				
Plantspecifieke detectie in de akkerbouw							x	x			
kosten besparend							x				
kleine doses mest toe te dienen							x		x		
Geïnjecteerd in de wortelzone									x		
Op harde kleigrond kan nog steeds worden geïnjecteerd							x				
Minder slijtage omdat niks door of in de grond gaat							x				
Wat zijn de nadelen?							5A	1B	1H	1A	
Hoge kostprijs							x		x	x	
zware machine									x		
bediening vereist veel specialisme										x	
Wat moet er nog gebeuren?							5A	1B	1H	1A	

sensoren voor analyse van plaatsspecifieke behoefte moeten verder worden ontwikkeld	x	x		x
in economische zin aantrekkelijk worden	x			
melkveehouders moeten gedwongen worden de mineralenefficiëntie te verhogen			x	
kennis van behoeftes en beste meststoffen moet verder ontwikkeld worden		x		x
Machine moet worden doorontwikkeld voor toepassing op grasland	x			
Wanneer in de praktijk?	5A	1B	1H	1A
over minimaal 2 jaar is de machine in technische zin klaar voor toepassing mét sensoren voor het analyseren van de behoefte	x	o		
over 10 jaar		x		
over 15 jaar				x
wanneer de plaatsspecifieke sensoren er zijn kan deze machine eventueel in de praktijk komen			x	

Mestverwerking zodat drijfmest als kunstmest kan worden gebruikt

Voordelen?	1G	1C	1I	4E
Veel meer afzetkanalen voor de verwerkte mest t.o.v. drijfmest	x		x	
de verwerkte mest kan verder getransporteerd worden	x			
de verwerkte mest heeft een betrouwbare werking	x			
Het mestoverschot neemt hierdoor af			x	x
de efficiëntie van eigen mest gaat omhoog		x		
er mogen meer dieren worden gehouden		x		
minder kunstmest nodig, meer dierlijke mest benut				x
Wat moet er nog gebeuren?	1G	1C	1I	4E
De verwerkingstechniek moet verbeterd worden qua efficiëntie en output	x	x	x	x
De kosten van het proces moeten omlaag	x		x	
Veranderen van de wetgeving		x		x

Welke bedrijven gaan mest verwerken?	1G	1C	1I	4E
op zichzelf staande bedrijven			x	
kunstmestfabrieken	x	o	o	
meststoffenleveranciers			x	x
boerencoöperaties			x	

Wanneer in de praktijk?	1G	1C	1I	4E
zodra het efficiënt en in een interessante meststof kan worden omgezet	x	x	x	x
binnen 5 tot 10 jaar			x	
wanneer de wetgeving het toelaat als kunstmest				x

Drone bemesting

Voordelen?	1H	3D
Meerdere malen kleine giften naar plaatsspecifieke behoefte geeft een hogere mineralenefficiëntie	x	x
arbeidsbesparing	x	x
geen insporing	x	x

Welke stappen moeten nog worden genomen?	1H	3D
de plaatsspecifieke behoefte moet goed kunnen worden geanalyseerd	x	x
de toepassing van bemesting moet ontwikkeld worden voor drones, defensie kan hierbij een voorbeeld vormen (bommen etc.)	x	x

Wanneer in de praktijk	1H	3D
Over 7 tot 10 jaar zonder subsidies werkzaam		x

Gevolgen	1H	3D
Loonwerkers worden deel dronebestuurders en -onderhouders	x	

Robot bemesting

voordelen?	1B	2D	2E	1A
Arbeidsbesparing	x		x	x
minder bodemverdichting	x			x
hogere mineralenefficiëntie door meerdere giften		x		x
preciezer			x	
Nadelen?	1B	2D	2E	1A
Hoge kosten		x	x	
storingsgevoelig			x	
andere gevolgen?	1B	2D	2E	1A
Loonwerkbedrijven hebben minder bestuurders nodig en meer				
hogergeschoolde robot-specialisten		x		x
Het zal de huidige machines verdringen uit de markt				x
Wat moet er nog gebeuren?				
de machines moeten ontwikkeld worden	x		x	x
Wanneer in de praktijk?	1B	2D	2E	1A
met de huidige bemestingsmethodes binnen 10 jaar	x			
over 10 jaar met plaatsspecifieke bemesting	x			
binnen 15 jaar volledig geautomatiseerde robots				x
over 15 jaar op zijn vroegst			x	
Helemaal niet omdat deze te duur zijn		x		

Druppel irrigatie

Voordelen:	1B
geen droogte stress meer	x

vergroot het opbrengstpotentieel aanzienlijk	x			
meststoffen en water worden geleidelijk toegediend	x			
geen bodemverdichting	x			
nadelen?	1B			
buizen in het grasland	x			
Hoge kosten voor systeem en computer	x			
Wat moet er nog gebeuren	1B			
er moet in eerste instantie in geloofd worden zodat het geprobeerd wordt	x			
onderzoek naar bodemprocessen is hiervoor essentieel	x			
Wanneer in de praktijk	1B			
Niet te zeggen, er is niemand mee bezig nu	x			
ontwikkelingen van sensoren voor bodem, gewas, mest en kunstmest				
Welk type sensoren wordt gevraagd in de toekomst?		1C	1E	1D
die de plaatsspecifieke behoefte van plant en bodem kunnen bepalen		x	x	x
sensoren die exact meten wat je aan mineralen uit drijfmest uitrijd		x		
Urine en mestplekken herkennen				x
Wat zijn de voordelen van dergelijke sensoren?		1C	1E	1D
Plaatsspecifieke behoefte weten en exact weten wat je toedient maakt plaatsspecifieke bemesting				
mogelijk, dit zorgt voor een verhoging van de mineralenefficiëntie		x	x	x
Welke stappen moeten nog worden genomen?		1C	1E	1D
de huidige sensoren moeten worden doorontwikkeld		x	x	

de vertaling van de meting naar de behoefte moet beter			x
Wanneer in de praktijk	1C		
ontwikkelingen op dit gebied gaan heel snel de komende jaren omdat de technieken al veel in andere		1E	1D
sectoren worden gebruikt	x	x	
plaatsspecifieke bodembehoefte is niet binnen 5 jaar beschikbaar		x	
plaatsspecifieke kwaliteitsmeting van gras is er binnen 5 jaar		x	
Urineplekken mijden is al operationeel op kleine schaal			x
Welk type bedrijven ontwikkelt deze	1C	1E	1D
de machinebouwers zelf	x	x	
gespecialiseerde bedrijven		x	

Meer gebruik en verwaarding van reststromen

voordelen?	1G	3B	1C	1I	2E	2C	1J	4F
Zo efficiënt mogelijk omgaan met energie, water en bestaande stromen	x							
minder druk op het milieu	x							
de kringloop wordt meer sluitend	x	x		x				
minder kunstmestproductie en transport (milieu)		x		x	x	x		x
beter imago		x						
lagere kostprijs t.o.v. kunstmest			x		x	x	x	x
makkelijke aanvoer			x					
meer natuurlijke producten voor bemesting				x				

Nadelen?	1G	3B	1C	1I	2E	2C	1J	4F
Meststoffen niet altijd homogeen				x		x		
lage concentraties van meststoffen in de reststromen				x				
Wat voor een type bedrijven zullen reststromen gaan verwaarden?	**1G**	**3B**	**1C**	**1I**	**2E**	**2C**	**1J**	**4F**
meststoffenleveranciers	x	x		x	x	x		x
mestintermediairs						x	x	
kleine kunstmestfabrieken					x			
Coöperatie van boeren				x				
gespecialiseerde reststroomverwaarders							x	
Welke bedrijven worden hierdoor beïnvloedt?	**1G**	**3B**	**1C**	**1I**	**2E**	**2C**	**1J**	**4F**
meststoffenleveranciers zien afzet dalen	x	x			x			x
meststoffenleveranciers hebben kansen in nieuwe/bredere markt	x	x		x			x	x
kunstmestfabrieken zetten minder af			x	x	x			
loonwerker moet investeren in vloeibare toediening, opslag en transport			x		x			
de producenten van de reststromen hebben hier voordeel van				x				
Melkveehouders hebben meer keuzemogelijkheden					x			x
Melkveehouders kunnen reststromen krijgen voor een lagere prijs dan kunstmest						x	x	
Loonwerker kan meer werk krijgen door te investeren in vloeibare toediening					x	x		
intensieve varkens en kippen bedrijven kunnen meer met de afvalstromen								x

Wat moet er nog gebeuren?	1G	3B	1C	1I	2E	2C	1J	4F
wettelijke beperkingen moeten worden opgeheven	x						x	
de logisitiek en opslag van reststromen moet praktischer worden					x			

meer reststromen moeten worden toegestaan als kunstmest						x		x
meer onafhankelijke voorlichting aan melkveehouders						x		
de regelgeving omtrent het op maat maken van reststromen moet versoepeld worden							x	
de samenstelling van reststromen moet meer worden geanalyseerd							x	x
De benutting van deze reststromen moet worden onderzocht							x	
Tussen welke bedrijven zullen samenwerkingen ontstaan?	1G	3B	1C	1I	2E	2C	1J	4F
er zal (bijna) altijd een intermediair tussen reststroomproducent en reststroom gebruiker zitten	x					o	x	x
ketensamenwerkingen tussen reststroomproducenten, meststoffenleveranciers en reststroomgebruikers		x	x					
reststroomgebruikers gaan samenwerken om dit in te kopen				x				
verwaarders en producenten van reststromen gaan samenwerkingsverbanden aan					x			

Biologisch aanzuren van mest d.m.v. bacteriën

Welke bacterie	1G
Lactobacillus spp.	x
voordelen	1G
verminderde ammoniakemissie	x
betere benutting van mest in biogasinstallatie	x
Hoeveel % kan worden gereduceerd	1G
54 tot 66% uit recent onderzoek gebleken	x
Nadelen	1G
Het kostenplaatje om meer dan 50% van de ammoniakemissie te reduceren is erg hoog.	x
Wanneer in de praktijk	1G
met 2 tot 3 jaar tijd mits voldoende financiering voor onderzoek	x

Fosfaatrechten

Voordelen 3E 3B 1C 4F
4J

melkveehouders worden gestuurd zo efficiënt mogelijk met fosfaat om te gaan, voordeel voor bedrijf en milieu x x
x

voer en meststoffenleveranciers kunnen hierop inspelen door zoveel mogelijk efficiëntie aan te bieden x

Nadelen 3E 3B 1C 4F
4J

Melkveehouders moeten een grotere investering doen om uit te kunnen breiden x

de markt is gebonden en de groei beperkt x x x

wat zijn de overige gevolgen 3E 3B 1C 4F
4J

De melkveehouders gaan zo efficiënt mogelijk met fosfaat om, zodat er meer dieren mogen worden gehoudern en daardoor meer kan worden geproduceerd x
x

De kringloopwijzer wordt een zeer belangrijke tool omdat meer dieren mogen worden gehouden, dus meer kan worden geproduceerd, wanneer de kringloop efficiënt isx x x

Er gaan meer melkveehouders op korte termijn stoppen die geen opvolger hebben x

de grondprijzen stabiliseren i.p.v. verder stijgen x

Er komt een handelsstroom van fosfaatrechten op gang x

Wat is het effect hiervan op weidegang 3E 3B 1C 4F
4J

Weidegang zal afnemen omdat opstallen efficiënter is met het oog op fosfaat x x o o

Het is afhankelijk van veel factoren, per saldo zal het niet uitmaken x

Mestwetgeving wordt verder aangescherpt

Waarom (niet) 1G 2B 1I 1A 4E 3C

Het is afhankelijk van het feit of de nitraatrichtlijn gehaald wordt x x x x

de gebruiksnormen worden verder aangescherpt omdat de nitraatrichtlijn niet gehaald wordt	o			x			
Niet zozeer aangescherpt, maar aangepast; er zal meer gedifferentieerd worden op bedrijfsniveau				x	x		
de gebruiksnormen worden niet verder aangescherpt omdat het nu met fosfaatrechten zeer ingeperkt is.			x			x	
de uitrijmethode van mest met water wordt verplicht		x	o			x	
de normen worden niet aangescherpt omdat ze nu al aan de ondergrens zitten					x		
Wanneer:							
Alleen als de dieraantallen sterk toenemen zal de mestwetgeving worden aangescherpt	x						
In 2020 met de invoering van het nieuwe landbouwbeleid	x	x	x	x			
In 2018 bij het volgende nitraat actieprogramma					x		
Hoe:							
de mestwetgeving wordt meer gedifferentieerd waarbij probleemgronden (als droge zandgrond) verder beperkt worden				x			
de gebruiksnormen worden meer gedifferentieerd op bedrijfsniveau, de prestaties van het bedrijf zijn hiervoor bepalend					x		
Voor elke toedieningsmethode wordt een verplicht minimaal percentage water vastgesteld		x					
Mest bovengronds uitrijden met water zou een toegestane methode kunnen worden			x				
De gebruiksnormen van fosfaat en stikstof worden naar beneden bijgesteld	x						
met name nitraatstikstof wordt beperkt				x			
Bewerkte drijfmest mag als kunstmest gebruikt worden en moet worden uitgereden met water						x	
Gevolgen							
als de gebruiksnormen worden aangescherpt zal de productie per hectare afnemen	x	men kan minder dieren houden met hetzelfde aantal hectares	x	groei wordt nog lastiger voor melkveehouderijen	x		
als mest uitrijden met water verplicht wordt leidt dit tot grote investeringen bij loonwerkers waardoor de kosten voor melkveehouders ook zullen stijgen	x	als mest uitrijden met water een optie wordt kunnen loonwerkers zich onderscheiden en hebben melkveehouders meer keuzemogelijkheden	x				

als de gebruiksnormen afhankelijk zijn van mineralenefficiëntie op bedrijfsniveau dan zouden melkveehouders zich hier nog meer op richten	x	
als de gebruiksnormen afhankelijk zijn van mineralenefficiëntie op bedrijfsniveau dan zullen de nitraatgehaltes in het grondwater verder dalen	x	
als de gebruiksnormen afhankelijk zijn van mineralenefficiëntie op bedrijfsniveau dan zullen adviseurs een rol kunnen spelen in het verhogen van de mineralenefficiëntie	x	
als bewerkte drijfmest als kunstmest mag worden uitgereden dan zal er minder kunstmest worden aangekocht		
als bewerkte drijfmest als kunstmest mag worden uitgereden dan wordt de kringloop meer gesloten		x

Koeien gevoerd op basis van DNA

Hoe	1H
de dieren worden gefokt op voerefficiëntie	x
uiteindelijk zullen dieren individueel gevoerd worden met de voeding die ze zeer efficiënt kunnen omzetten volgens hun DNA	x

Voordelen	1H
De voerefficiëntie kan worden verhoogd	x
de benutting van nutriënten gaat omhoog waardoor de kringloop positief wordt beïnvloedt	x
er kunnen meer dieren worden gehouden op hetzelfde aantal hectares	x

Productie per hectare daalt door te strenge gebruiksnormen

Is dit zo?	1B	1E	1A
Ja	x		o
Het is lastig te zeggen omdat het van zoveel factoren afhankelijk is	x	x	

Wanneer kunnen we deze gevolgen verwachten	1B	1E	1A
Dit speelt al	x		
als de gebruiksnormen nog lager worden is de kans nog veel groter		x	

Hoe kan dit worden voorkomen of bestreden?	1B	1E	1A
door de benutting van mineralen te verhogen	x	x	x
melkveehouder moet meer kennis en inzicht krijgen van de eigen situatie	x		
plaatsspecifieke bemesting kan in de toekomst de mineralenefficiëntie verhogen		x	x
de benutting van kunstmest moet verhoogd worden			x
meer rekening houden met de weersvoorspellingen		x	
meststoffen injecteren in de wortelzone		x	

Een lage CO2 equivalent per kg melk wordt in de toekomst beloond

Hoe zal dit eruit zien?	1G	1C	4G	4J	4I
er zal op worden gestuurd d.m.v. een CO2-taks vanuit de overheid	x				
de overheid gaat belonen of straffen o.b.v. CO2 uitstoot van melkveehouderijen		x			
De overheid stelt een CO2 plafond in voor melkveehouderijen en zuivelfabrikanten		x			
in eerste instantie wordt het beloond door zuivelfabrikanten, wanneer dit niet werkt zal de overheid ingrijpen			x		
het wordt inmiddels al een beetje beloond via het kwaliteitssysteem van de zuivelfabrikant, dit zal toenemen				x	
als de consumenten er ook de meerwaarde van inzien zal het beloond worden door de zuivelfabrikanten		o			x
Wanneer zou dit kunnen worden ingevoerd?	**1G**	**1C**	**4G**	**4J**	**4I**
binnen een paar jaar zal de melkveehouder worden gestimuleerd of gedwongen CO2-uitstoot te reduceren			x		
Het is heel lastig in te schatten, het zou kunnen dat meerdere concurrerende zuivelfabrikanten dit integraal oppakken; dit zou de komst van een beloningssysteem versnellen					x
Hoe kan dit worden gemeten?	**1G**	**1C**	**4G**	**4J**	**4I**
middels een systeemanalyse van het bedrijf	x		x		
met behulp van de kringloopwijzer				x	x
In de toekomst misschien in de melk zelf				x	
Wat zijn de gevolgen?					
Melkveehouders kiezen bewust voor een lagere CO2 voetafdruk; hier worden ze zelf en het milieu beter van	x				x
Het inkomen van melkveehouder zal dalen omdat zij investeringen moeten doen om onder het opgelegde CO2 plafond te blijven		x			
Nederland kan zich internationaal onderscheiden door CO2-bewuste melkproducten te verkopen			x		
de productie van broeikasgassen uit de zuivelketen zal afnemen				x	
melkveehouders reduceren de broeikasgassen tot een niveau dat voor hen het meest rendabel is				x	
Welke bedrijven profiteren hiervan					
de hele zuivelketen profiteert van een beter imago	x				
toeleveranciers en ontwikkelaars die producten leveren met een lage CO2 voetafdruk	x	x	x	x	x

De melkveehouders hebben meer advisering nodig om CO2 reductie te realiseren		x			
de melkveehouders profiteren van een premie als ze CO2 reductie realiseren			x	x	
de zuivelfabrikanten hebben een nieuw marketinginstrument			x	x	
Verhoogde eiwit productie per hectare grasland door precisiebemesting					
Waarom?	4F	4G	1D	1A	4E
de eiwitproductie gaat omhoog omdat de totale grasproductie wordt verhoogd door plaatsspecifieke bemesting	x	x	x		
het eiwitgehalte wordt verhoogd door meer toediening van ammoniumstikstof en amidestikstof ten opzichte van nitraatstikstof	o			x	
de benutting van mineralen gaat omhoog door beter te timen a.d.v.h. weersvoorspellingen			x		
de eiwitproductie gaat omhoog omdat de totale grasproductie wordt verhoogd door een preciezere plaatsing van de meststoffen				x	
Voordelen?	4F	4G	1D	1A	4E
milieuvoordeel omdat er minder mineralen verloren gaan	x	x	x	x	
milieuvoordeel omdat er minder aanvullend (eiwitrijk) voer hoeft worden aangekocht; productie en transport	x				x
kostenbesparing voor de melkveehouder omdat deze minder aanvullend (eiwitrijk) voer hoeft aan te kopen	x		x	x	x
meer melkproductie van eigen voer			x		
de afhankelijkheid van buitenlandse voederstromen neemt af			x		
de mineralenbalans/kringloop wordt positief beïnlvoedt omdat er minder aanvullend voer hoeft worden aangekocht		x		x	
Beter voor de gezondheid en welzijn van de koe				x	
een betere mineralenbalans/kringloop zorg voor het mogen houden van meer dieren i.v.m. fosfaatrechten				x	
Zijn er nog stappen die genomen moeten worden om dit te realiseren?	4F	4G	1D	1A	4E
Plaatsspecifieke bemesting is een vereiste	x	x	x	o	o
de infrastructuur moet worden aangepast naar vloeibare meststoffen als blijkt dat deze een hogere efficiëntie halen			x		
de voorlichting moet richting een zo hoog mogelijke productie i.p.v. een zo hoog mogelijke afzet van hun producten				x	
Welke bedrijven worden hier positief of negatief door beïnvloedt?	4F	4G	1D	1A	4E

De voerleveranciers zullen minder aanvullend voer verkopen						x x x x x
melkveehouderijen worden meer zelfvoorzienend en besparen kosten						x x x x
melkveehouderijen verbeteren de mineralenkringloop waardoor ze meer dieren mogen houden						x x x
de producenten/handelaren van eiwitrijke voeders als soja en raapzaadschroot hebben minder afzet (deze bedrijven zijn dermate groot dat de effecten niet heel groot zijn)						x x
Doordat meer dieren mogen worden gehouden groeit de afzet voor voerleveranciers weer						x
Veevoederleveranciers kunnen hoogwaardiger voer verkopen						x
er zal meer vraag zijn naar onafhankelijke adviseurs						x
de producenten van preciebemesters en toepassingen daarvoor krijgen meer afzet						x
Toevoegingen aan het voer zullen de productie van broeikasgassen door koeien reduceren						
Welke toevoegingen?	4A					
Er is een poeder ontwikkelt door DSM, echter is nog niet naar buiten gebracht wat het precies is.	x					
Welke stappen moeten nog worden gezet	4A					
de stap van functioneren in het lab naar functioneren in de praktijk moet worden gemaakt	x					
Welke bedrijven kunnen deze toevoegingen leveren	4A					
Biochemische bedrijven zoals DSM	x					
Wat zijn de gevolgen?	4A					
Imago verbetering van de gehele zuivelketen	x					
er komt een markt voor broeikasgasreducerende toevoegingsmiddelen	x					
Verplichte reductie van broeikasgassen						
Hoe wordt deze regelgeving ingevuld?		4J	1D	4I	1C	3A
Er komt een broeikasgasplafond op bedrijfsniveau net als bij fosfaat komt		x		x		
methaanproductie wordt als eerste aan banden gelegd worden			x			
het zal met name worden geuit in generieke maatregelen voor de sector			x			

de kringloopwijzer wordt hierin leidend, deze wordt aangepast voor de emissies die er nu niet in meegenomen worden				x	x
Door wie wordt de verplichte reductie opgelegd	4J	1D	4I	1C	3A
vanuit de Europese unie		x	x		
vanuit de Nederlandse overheid	x			x	x
Door de zuivelketen zelf	x				
Wanneer wordt de regelgeving ingevoerd?	4J	1D	4I	1C	3A
over 4 jaar zijn de eerste signalen bekend		x			
voorlopig niet, tenzij er nieuwe internationale verdragen gesloten worden	x				
Per 1 januari 2016 wordt de kringloopwijzer voor alle melkveehouders verplicht				x	
In de toekomst wordt de kringloopwijzer voor alle melkveehouders verplicht					x
Wat zijn de consequenties hiervan	4J	1D	4I	1C	3A
De productie van broeikasgassen door de zuivelketen zal afnemen	x				
melkveehouders reduceren de broeikasgasproductie tot het niveau van het plafond, niet verder.	x				
De methaanproductie zal afnemen		x			
de melkveehouders moeten investeringen doen		x			
reductie van broeikasgassen kan in een versnelling raken omdat melkveehouders nu moeten investeren i.p.v. vrijwillig			x		
hoe meer reductie hoe meer dieren gehouden kunnen worden				x	x
Welke bedrijven hebben hier voor- of nadeel van?	4J	1D	4I	1C	3A
zuivelfabrikanten hebben een marketinginstrument, zeker wanneer zij het opleggen	x				
producenten en adviseurs in broeikasgasreducerende producten en methodes krijgen een veel grotere markt in de zuivelketen	x		x	x	x
melkveehouders moeten investeringen doen	x				x
melkveehouders worden nog meer beperkt in groei	x				

extensieve melkveehouderijen hebben extra nadeel omdat zij veel koolstof voeren	x									
voerleveranciers met methaanreducerende voeders hebben meer afzet	x									
front-runners hebben hier voordeel van, zowel de melkveehouders als de toeleveranciers van reducerende methoden/producten		x								
kleinschalige bedrijven kunnen in de problemen komen doordat ze te grote investeringen moeten doen		x								
Melkveehouders kunnen meer productierechten verkrijgen door het extra goed te doen (in geval van kringloopwijzer-uitbreiding)			x	x						
Beweiding										
Wat gaat er procentueel gebeuren?					3B	1J	4F	4I	4E	
Het percentage blijft gelijk, tenzij het nog meer gestimuleerd wordt door overheid of zuivelfabriek					x				x	
Het zal moeten stijgen naar 80%, gebeurd dit niet goedschiks met belonen dan wel kwaadschiks met verplichten						x				
over 10 jaar is het 100 procent omdat weidegang verplicht wordt door de overheid als de zuivelfabrikanten het niet voor elkaar krijgen met belonen							x	o		
het gaat naar het niveau waarop de koe het prettig vind								x		
Hoe wordt het percentage gestimuleerd?					3B	1J	4F	4I	4E	
weidepremie betaald door de zuivelfabrikant					x	x	x	x	x	
in de toekomst eventueel een aanvullende weidepremie betaald door de overheid					x					
de beloning wordt toonaangevend						x				
De overheid gaat beweiding afdwingen op het moment dat de zuivelsector het zelf op het gewenste niveau krijgt						x	x		o	
bij studieavonden van jonge veehouders komt beweiden vaak positief aan bod								x		
Nadelen van beweiding					3B	1J	4F	4I	4E	
minder voeropbrengst					x			x	x	
de mineralenefficiëntie is lager en daarmee wordt de kringloop negatief beïnvloed (dus het milieu)					x	x		x		
beperking bij schaalvergroting									x	
minder arbeidsefficiënt (vanwege het graslandmanagement)									x	
Invloed van beweiden op emissies?										

nadelig voor de mineralenkringloop													x		
verminderde ammoniakemissie													x	x	x
per saldo vermoedelijk geen verschil															x

Melkveehouders en zuivelfabrikanten produceren energie voor zichzelf en voor anderen

Zie je dit gebeuren?	3E	1I	4G	4J	4I
Ja, vooral melkveehouders vanwege stimulans van zuivelfabrikant en overheid	x				
Ja, omdat er in de zuivelketen veel land- en dakoppervlak is		x			
Ja, vooral melkveehouders vanwege het dakoppervlak en energie uit mest			x		
Ja, afhankelijk van de economie en de subsidies				x	
Ja, zuivelfabrikanten kunnen zelf energie produceren, maar ook afnemen van 'hun' melkveehouders				x	
Ja, melkveehouders zullen met name energie produceren, zuivelfabrikanten zullen meer besparen					x

op welke manier produceren ze energie?	3E	1I	4G	4J	4I
Zonne-energie wordt de meest gebruikte methode van energie opwekken	x		x	x	
Windmolens zullen veel gebruikt worden		x		x	x
Er wordt energie gewonnen uit mest		o	x	x	x

Op welke termijn is de Nederlandse zuivelketen energieneutraal?	3E	1I	4G	4J	4I
de snelheid is erg afhankelijk van subsidies, energieprijs en terugverdientijd		x	x	x	
energieneutrale productie is over 5 jaar op veel melkveebedrijven het geval		x			
over 2 generaties is de melkveehouderij zelfvoorzienend					
de eerstkomende 10 jaar zal de zuivelketen nog niet energieneutraal zijn					
tussen de 5 en 15 jaar is de Nederlandse zuivelketen energieneutraal van melkveehouderij tot aan de retailer					

Welke bedrijven worden hierdoor beïnvloed?	3E	1I	4G	4J	4I
de producenten en onderhouders van zonnepanelen en andere energieopwekkende methoden krijgen een grotere markt	x			x	
energieneutrale productie en verwerking is voor de gehele zuivelketen iets waarmee ze zich kunnen onderscheiden in de markt			x		x
de bestaande energieleveranciers kunnen minder leveren	x	x	x	x	
de bestaande energieleveranciers krijgen het heel zwaar en zullen saneren	x				
de oliehandel zal gaan concurreren met alternatieve energie waardoor de prijzen zullen dalen		x			
melkveebedrijven hebben een extra inkomensstroom					x
de bestaande energieleveranciers zouden er ook aan kunnen verdienen door het management van deze energiestroom in handen te nemen					x

Preventieve antibiotica wordt verboden in de melkveehouderij

Waarom (niet)?	1D	4A	4I
een daadwerkelijk verbod is de vraag, een lager maximum van dierdagdoseringen lijkt waarschijnlijker	x		x
het zou goed kunnen omdat het antibioticagebruik op dit moment zeer hoog is.		x	
waarschijnlijk niet omdat de sector het zelf reguleerd			x
waarschijnlijk niet omdat steedst meer alternatieve geneesmiddelen zich aandien			x
Gevolgen?			
dierdagdosering zullen afnemen	x		
alternatieve geneesmiddelen zullen meer gebruikt worden	x	x	x
er komt meer aandacht voor gezonde voeding	x		
de gezondheid van de koeien zal beter individueel gemonitord worden	x		x
het uitvalspercentage stijgt doordat de hoge celgetal koeien eerder geruimd worden	x	x	
Wanneer?			
Binnen 5 jaar zal zeker een verscherping zijn van de wetgeving voor dierdagdoseringen	x		

over 5 tot 10 jaar wordt preventieve antibiotica afgeschaft					x	
Welke bedrijven hebben hier voor- of nadeel van?						
de veeartsen hebben hier nadeel van omdat zij verdienen aan antibiotica				x		
de veeartsen zouden ook voordeel kunnen halen uit meer bedrijfsbezoeken om de diergezondheid te verhogen				x		
de farmaceutische industrie omdat zij minder antibiotica verkopen				x		x
de producenten van alternatieve geneesmiddelen krijgen meer afzet				x	x	x
De farmaceutische industrie zou het aanbod kunnen verbreden met alternatieve geneesmiddelen				x		
de burger heeft hier voordeel van omdat de antibiotica resistentie minder groeit				x		
voerleveranciers die alternatieve voeding aanbieden voor de gezondheid krijgen meer afzet						x
producenten van individuele koesensoren zullen meer afzet krijgen						x
Melkveehouderijen met een hoge melkproductie per koe hebben hier nadeel van					x	
Alternatieve geneesmiddelen worden meer gebruikt						
Wat voor een geneesmiddelen?	4A	5B				
Homeopathische geneesmiddelen	x					
Allicine		x				
Waarom worden ze meer gebruikt?						
vanwege het maximaal aantal dierdagdoseringen antibiotica dat melkveehouders mogen toepassen	x	x				
Het gebruik van antiobiotica brengt de humane sector in het geding		x				
Allicine heeft een veel groter slagingspercentage t.o.v. antibiotica bij mastitis		x				
Wat zijn de voordelen?						
De homeopathische middelen tellen niet mee voor de dierdagdoseringen	x					
de melk van koeien die behandeld zijn met homeopathische middelen mag gewoon worden geleverd	x					
Allicine heeft een groter slagingspercentage		x				

met Allicine komen geen resistente bacteriën voor antibiotica		x
Welke bedrijven hebben hier voor- of nadeel van?		
De homeopaten zijn natuurlijk gebaat bij meer afzet	x	
de veterinaire sector verkoopt minder antibiotica en heeft daardoor minder winst	x	x
de melkveehouder profiteert van homeopathische middelen als ze effect hebben	x	
de melkveehouders hebben voordeel omdat Allicine beter werkt		x

Annex 7: BMC liquid fertilizer injector

Key Partners	Key Activities	Key Resources	Value Proposition	Customer Relationships
Fertilizer suppliers	Production	Labour	More Kg dry matter per hectare	Service
Fertilizer producers	Development	Capital	Less fertilizer required	Consultancy
Feed suppliers	Research	Software	Less emission	Maintenance
Consultants of contractors	Marketing	GPS	Higher mineral efficiency	Delivery and start-up
Independent information agencies		Stainless steel	Full coverage of the field	
Research		Pumpsystem	Minimal overlap	
Media		Production facility	Higher protein yield per hectare	
Manure processors		Knowledge	Injection in rootzone of plant	
			More control on grass-quality	
			Less additional feed required	

Distribution	Marketing	Customer Segments	Cost Structure	Revenue Streams
Direct sales	Journals	Contractors	Development-costs	Sales of machine
Dealers	Research	Dairy farmers	Software	Maintenance
Trader	Media	Arable farmers	GPS	Consultancy
Fertilizer supplier	Direct marketing	Floriculture	Assembly	Data-sales
	Free publicity	Traders	Materials	Calibration
	Projects	Municipalities		Lease of machine
	Symposiums	Sports fields		Repair of machines
		Fertilizer suppliers		Sales of parts
				Contracting