Master Thesis

Working together for better water

A case study in Valtherbos-Noordbargeres on the potential of using co-creation to increase the willingness and ability of farmers for sustainable agricultural practices.

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Master thesis

Environmental and Infrastructure Planning
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Abstract

Drinking water in the Netherlands is famous for its high-quality standards and perceived as one of the safest of the world. A source of clean and safe drinking water has been stored in abundancy in the ground. Pollution and over extraction however can threaten these sources, therefore the EU implemented several policies (WFD) which ensures a long term safeguarding of water sources. The WFD obliges governments to take action to protect water extraction areas and decrease the pressure on water purification plants. Multiple threats for water quality persist in the Netherlands: agriculture, infrastructure, industry, etc. Physical aspects of water extraction areas also play an important role on the vulnerability. One area with a large single treat and a vulnerable physical situation is Valtherbos-Noordbargeres. An area with high agricultural influence placed on dry sandy soils without a covering layer between the top ground water and lower water levels. Co-creation is expected to be useful in aligning the water sector and the agricultural sector in the area. A case study which analysed 4 farmers participating in a project of the water sector was used to determine the possibility of using co-creation to increase the willingness and abilities of farmers for taking a lead in sustainable agricultural practices. It was however found that the analysed farmers participated in the project for reasons other than environmental concern. In fact, a large discrepancy between the perceived threats and importance for the area between the water sector and the agricultural sector has been found. It is still expected that co-creation is useful as an incentive for farmers in taking sustainable agricultural practices when used in an agroecological dynamic with a knowledge institute (which was hired by the water sector in the project). However, the current setup lacks the ability to change towards an agri-environmental paradigm in which farmers take the lead for better ground water quality and quantities.

Key words: Groundwater contamination, sustainable agricultural practices, co-creation, collaborative planning, willingness, abilities.

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List of abbreviations

EU	European Union
NECD	National emission directive
KRW	Kader richtlijn water
Minas	Mineralen afgifte systeem
WFD	Water Framework Directive
WMD	Water Maatschappij Drenthe

1 Introduction

1.1 Background

Water is a vital resource for sustaining life, the average Dutch citizen uses 107 litres per day (Waternet ,n.d). Clean healthy water from the tap is the norm, as Dutch drinking water companies provide one of the best water qualities around the world. This quality is ensured by a large supply of already high-quality ground water, and high-quality water purification plants. At the purification plants remaining contaminates are removed and checked to be within required levels. Removing contaminants from can be costly and for some even impossible. Therefore, the protection of groundwater as a strategic resource is necessary.

Legislation to protect water as a resource for future generations has been created in the form of the Water Directive Framework on EU level which has been implemented on national and regional administrative levels. On a national level this has been done via the 'waterwet' and the 'wet milieubeheer' (water law & environmental management law). Quality targets have been implanted via the 'besluit kwaliteitseisen en monitoring water' (BKMW, 2009) (resolution quality requirements and monitoring water), the BKMW is relevant for surface water. Groundwater is protected via the 'Grondwaterrichtlijn' (GWR; 2006/118/EG) (groundwater guideline). These legislations give protection to water in the Netherlands as a whole (Wuijts, et al. 2013). Water sources for drinking water have an extra legislative protection via the 'drinkwaterwet' (drinkwaterwet, 2009) (drinking water law) which is focussed on the sustainable safekeeping of drinking water (Versteegh, et al. 2010).

High quality drinking water is provided by local or regional drinking water companies. Different methods are applied to produce water that conforms to the high standards required by Dutch legislation. Surface water from lakes and rivers but also ground water is used as a source of water. Ground water in the Netherlands is perceived as a high-quality source with little pollutants present, surface water usually requires more cleaning before consumption (Smeets, et al. 2009). Therefore, a preference towards ground water is present, as well as the availability throughout most of the country as can be seen in figure 1.

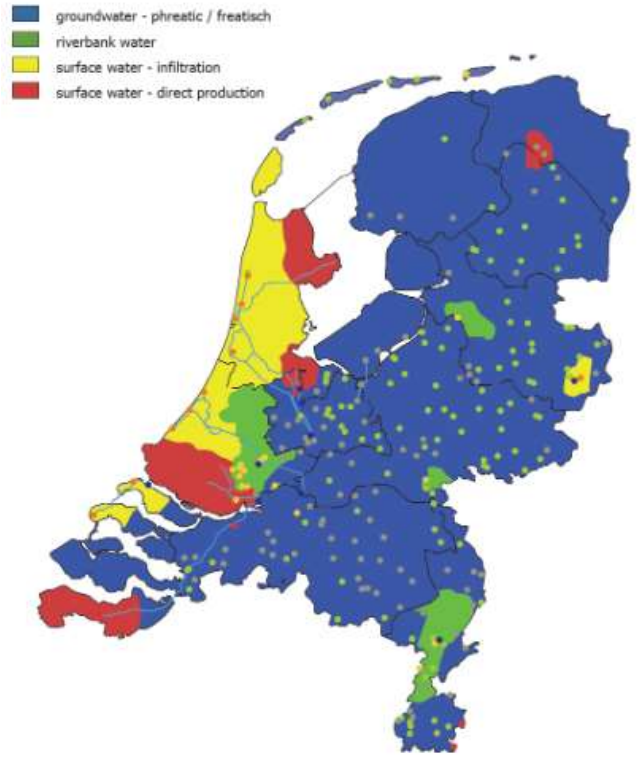


Figure 1 Source water types in the Netherlands. (Smeets, Medema, & Van Dijk, 2009)

The methods of cleaning water also differs from common practices around the world. The use of Chlorine in the water processing is probably familiar to anyone who spend some time abroad outside of western Europe. Dutch treatment facilities instead first start with groundwater or use some form of barrier filter for surface waters. Secondly it utilises physical processes such as sedimentation, filtration and UV-disinfection. The use of chemical treatment is minimalized and only if other methods fail can ozone of peroxide be used. The high quality, failsafe's and monitoring of the distribution network also play a vital role in the high standards of the water supply chain (Smeets, et al. 2009).
The main source, ground water, however is under pressure from a myriad of threats which influence the quality and quantity. For example climate change can cause salination at the coast or droughts in the inlands, industrial processes dump or leach chemicals into surface water of the soil and citizens use pesticides to remove weeds from their concrete gardens. This research focusses on another thread, the leaching of surplus nitrates into the ground water from agricultural sources. Surplus levels of nitrates have been present in areas of intensive agriculture for a long period and are expected to remain present in the next decennia (Lægreid et al. 1999 & Claessens et al. 2017). Nitrate levels are closely related to phosphates as they are both present in (synthetic) fertilizers.
The World Health Organization has guidelines for the maximum nitrate level of 50mg/L as a safe level, however some studies link even lower levels of nitrate to the illness of Methemoglobinemia. This is an affliction where infants red blood cells bind with nitrite (form of nitrate) and cannot bind to oxygen any more resulting in a blue skin colour and anoxia of the body (Avery, 2001; Johnson & Kross, 1990; Knobeloch, Salna, et al. 2000).
Not only infants can be susceptible towards illness related to a higher level of nitrates, the impact of nitrate can also increase the risk of colon cancer for adults (van Grinsven, et al. 2010). The statistical proof however is difficult as the increase in cancer cases remain small (De Roos, et al. 2003; Yang, et al. 2007). Van Grinsven, et al (2010) however claim a financial basis to decrease the 50mg/L level even based on the relatively small number of colon cancer cases that are expected to be the result of the current nitrate levels in the EU. A total of 3,5% of Dutch citizens could be at heightened risk of colon cancer due to higher than average levels of nitrate in the provided drinking water.
The risks of nitrates are not only present for humans, the safe levels for invertebrates (worms, snails etc.) is only 10 mg/L as size of the subject directly influences the acceptable amount. Fresh water lakes might need levels as low as 1 or 2 mg/L in order to maintain a diverse and complete plant life (Van Grinsven, et al. 2006). Besides nitrate has a direct impact as it also influences other elements in the soil. An increase in nitrate can lead to an increase in calcium, magnesium, sulphate, potassium, chlorides, and trace elements as zinc, copper, arsenic, cobalt or nickel. These do depend on the presence of materials in the soil such as pyrite, siderite, organic materials and chalk (van der Aa, et al. 2014). More research into the affects will be required to eliminate the uncertainties that occur in current researches. Otherwise all statements have to be based on non-conclusive assumptions (Powlson et al., 2008). This research does not make claims towards correctness of the levels of nitrate in regulation. Instead it focusses on how to achieve a maximum nitrate level of 50mg/L, by stimulating farmers and facilitating a co-creation with the water sector

1.2 Problem statement

Several areas in the Netherlands face problems regarding nitrate levels as can be seen in figure 2. These areas could all be of interest to analyse, however within this research only one specific area was chosen. The area of Valtherbos-Noordbargeres in south-east Drenthe is vulnerable and currently fluctuates around the limited set by the European union (see chapter 2 for more in depth information). The water sector and individual farmers already work together on several subjects such as manure and pesticides in the area in project groups. These project groups however are not mandatory and only farms with an area larger than 5 acres can participate. In these projects, several farmers get supervision and guidance from an external expert, but it also prohibits direct constructive interaction between the water sector and the farmers. The way current project groups work raises questions on the

effectiveness and inclusiveness. It also raises questions on how conflicts of interest between farmers and the water sector can be expressed in an open setting.
It has been suggested that co-creation can support problem solving within complex settings. Co-creation has been linked to building willingness and ability by understanding and supporting other stakeholders. Willingness and ability of stakeholders have been factors in decision making: higher willingness in combination with ability could lead to more sustainable agricultural practices taken on by farmers. Current project groups are taken as the basis in this research to analyse the current willingness and ability and the potential for improvement. In conclusion, the aim of this study is to gain insight in the usefulness of co-creation and how it can increase the willingness and abilities of farmers to take the lead to perform sustainable agricultural practices.
The water sector in this project is represented by the Province of Drenthe and Water Maatschappij Drenthe (drinking water company), a more in depth description of the roles and responsibilities can be found in chapter 2.

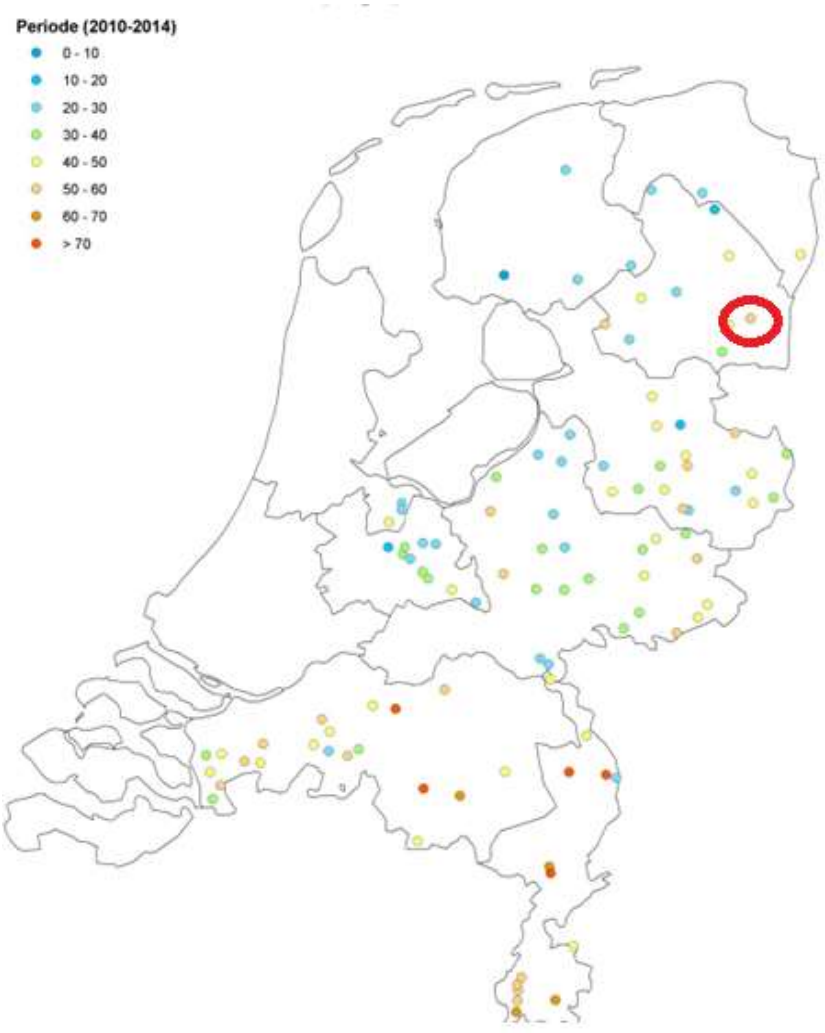


Figure 2 Area average nitrate concentrations 2010-2014, circled area Valtherbos-Noordbargeress (modified from Claessens et al. 2017)

The implementation of the Water Framework Directive from the EU legislation in national and regional levels is an example of top-down planning where higher authorities regulate lower authorities and citizens. Bottom-up approaches have a reverse flow, where citizens influence (higher) authorities. In the literature this form of planning is related to the communicative planning. Bottom-up approaches are best suited for local problems which have unique features. Top-down planning might not be suitable to accommodate all the different features of local diversities. The differences between the area of Valtherbos-Noordbargeres and other European areas should be clear to anybody looking at them, yet their water systems are both governed by the same Water framework directive. Bottom-up approaches requires citizens to take a leadership position and to challenge the government into participation on an equal level.
By providing a balanced co-creation setting, farmers will benefit from a stronger position in deciding their own future, as well as it will provide the water sector with an increased ability to mitigate water quality and quantity problems. Several research questions have been formulated to achieve this goal. These questions culminate into the primary research question of:

How can co-creation between farmers and the water sector support willingness and abilities for farmers to take the lead in sustainable agricultural practices improving water quality and quantity in South east Drenthe?

To be able to answer the primary research questions the following secondary questions are formulated:

"Generic questions"

1 Which water problems (quantitative and qualitative) are created by farmers in south east Drenthe, what are their spatial dimensions?
2 How is the governance on water structured?
3 Which stakeholders are part of the water sector in SE Drenthe?
4 What are 'sustainable agricultural practices', and how can these practices benefit groundwater quality?
5 What is co-creation, and how can it influence willingness and abilities of farmers to adapt?

"Empirical questions"

6 What are the willingness and abilities of farmers for taking the lead in sustainable agricultural practices?
7 What barriers for implementing sustainable agricultural practices are perceived by farmers?
8 What are the formal and informal relations between stakeholders?

1.3 Scientific relevance

A knowledge gap on the cases relating co-creation with water problems and the agricultural sector is present in current scientific literature. Farmers adapting sustainable practices for improving water quality cannot only be supported by generic solutions. Adaptation is strongly intertwined with the local context (Agrawal, 2010). Local initiatives can be helpful in creating sustainable solutions. As Soares da Silva et al. (2018) state 'place' is an important factor for local initiatives. The 'place' defines a large part of the possibilities of local initiatives. According to Horlings (2018) places are the arena's where actors, different groups of citizens and institutions interact. Not just the physical world, although that also plays a part here, but the connections between people and other stakeholders shape local initiatives. As shown before the current 'place' setting for the area of Valtherbos-Noordbargeres is shaped around the top-down influence of the EU Water framework directive. The complex nature of sometimes even contradicting goals and legislation do not favour this setting. The complex nature of nature cannot be grasped by statistics and numbers.

A shift towards communicative planning has been around for some years. Projects between government, farmers and drinking water companies can become a prime example of this shift. If communicative planning is used to grasp problems not as a single entity, but as the whole system of economics, ecology and society as dynamic entity, a level of optimal balance can be found. Continuing on the sectoral division between problems might solve some, yet create larger problems at other places in this balance.

Co-creation can be the instrument to connect and show these influences and problems in the dynamic system. This knowledge can lead to a better scientific understanding of the dynamic structures relating to the agricultural sector and the water sector. The literature on co-creation as a basis for generating willingness and abilities in sustainable agricultural practices is little and spread over a myriad of subjects and different 'place based' areas (de Olde, et al.2017; Hack-ten Broeke, et al. 1999; Raadgever, et al. 2011). This thesis adds to the small number of studies into collaborative planning methods used to mitigate agricultural environmental problems. Insight into the unique 'place' of Valtherbos-Noordbargeres cannot only benefit the area, but also give insight to planners in other unique areas where the agricultural sector greatly influences the environmental situation.

In conclusion, this research aims to apply the theoretical concepts of sustainable agricultural practices and co-creation in a concrete setting. By doing this it provides insights in the conditions for the willingness and ability of farmers to mitigate water quality and quantity problems. In doing this it contributes to the planning debate on communicative planning and the benefits of co-creation therein.

1.4 Societal relevance

The scientific relevance links into the societal relevance, the area of Valtherbos-Noordebargeress can be seen as unique in its place, however it is not unique in having water quality and quantity problems. As shown by Claessens et al (2017) in figure 3 the amount of water winning areas which have an increased amount of nitrate above 50mg/L is 28, if the preferred level of 25 mg/L (WMD, 2018) is used only 20 areas pass. The importance of a good connection and active participation from farmers becomes even more apparent when looking at the area used for farming in the Netherlands. Oenema et al. (2005) state that over 60% of land is used by agriculture, this land is intertwined with the water systems through the soil and surface water. Nitrate runoff, but also other problems such as pesticides and droughts therefore directly influence large portions of the country. Already in 1989 did Straatman claim: *"The chemical composition of groundwater in the Netherlands is strongly influenced by heavy applications of manure and fertilizer".* The research on Valtherbos-Noordbargeres can as such be helpful in generating a planning practice for place based communicative planning in the agricultural sector addressing water problems.

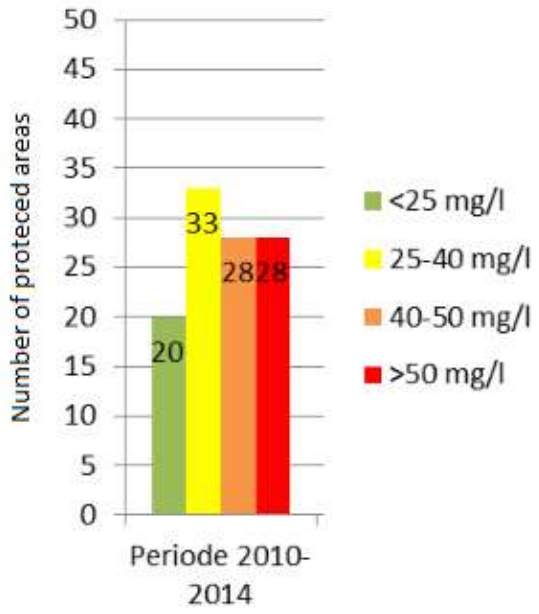


Figure 3 Nitrate levels in Dutch protected areas modified from Claessens et al. 2017

1.5 Outline thesis

Chapter one has been the introduction into the local setting of Valtherbos-Noordbargeres and the water quality and quantity problems of the area as the relevant issues and context of this thesis. Chapter one also included the research questions and societal and scientific relevance. Chapter two offers an overview of the theoretical debate water problems, water governance, co-creation and sustainable agricultural practices. Chapter three introduces the research methodology. Chapter four are the results of the empirical research. Chapter five is the conclusion and discussion on the research questions. Chapter six is a reflection on the research as a whole. Chapter 6 is followed by the list of references and appendix.

2 Theory

Chapter two answers four theoretical questions. 2.1 explains the current water quality and quantity problems and their relationship towards farming and spatial dimensions. 2.2 elaborates on the governance structure of water planning. 2.3 is about co-creation and how it can stimulate farmers into taking the lead in sustainable practices. 2.4 focusses on sustainable agricultural practices, what they are and how they can be used to improve water quality and quantity. 2.5 is the synthesis of the first four parts and defines the conceptual model.

2.1 water problems

Which water problems (quantitative and qualitative) are created by farmers in south-east Drenthe, what are their spatial dimensions? (Question 1)

Defining water problems

Water problems for this research are defined as all problems that negatively impact the quantity and quality of the groundwater in the protected area of Valtherbos-Noordbargeres. This excludes problems like high rainfall causing flooding of houses from this research. Water problems caused by other actors than farmers will also not be taking into account are beyond the scope of the research.

The role of farmers in creating water problems

The influence of farmers on groundwater is divided in two parts. First, extraction of water decreases groundwater levels, which affects water quantity and can lead to depletion of groundwater sources. Second, the pollution of ground water affects water quality. The main agricultural sources of pollution are pesticides and nutrients (Lægreid, Bockman, & Kaarstad, 1999; Hester, Harrison, & Barbour, 1996). Not every farmer uses the same amounts of water, pesticides and nutrients; differences in amounts, methods and even the location of application play a large role in the effect these have on ground water. Furthermore, solving water quantity problems can negatively influence water quality and vice versa. Depending on the area, quantity or quality can become the more pressing factor. The Netherlands has a large abundance of water, though not all is suitable for consumption and/or irrigation. Water shortage has become an issue in recent years since climate change can threaten existing ground water supplies (Oude Essink, Van Baaren, & De Louw, 2010). Climate change poses threats such as salinification and droughts. Salinification plays a large role in the coastal areas; droughts cause the largest impact in the eastern sandy grounds which are less capable of retaining water. Using water for irrigation can be forbidden in periods of drought (van Leerdam, 2019).

Pesticides are used for crop protection, synthetic pesticides such as DDT have been around since the 1940's (Hester, Harrison, & Barbour, 1996). Pesticides as DDT were seen as safe to humans, and have done amazing work in stopping some diseases and crop protection. Silent spring (Carson, 2002) was the turning point of DDT and a lot of other synthetic pesticides as the downside became clear. Via bioaccumulation the pesticides persisted in the food chain causing problems for birds and other species.

Figure 4 DDT as harmless to humans, Beach guest sprayed with DDT. Photo: Bettmann/Getty Images

Modern pesticides need extensive testing before being allowed on the market. Protected areas have even stricter rules on which products are allowed. New pesticides that are allowed on the market therefore do not automatically qualify for use within ground water protection areas.
Besides pesticides leaching towards ground water, nutrients that are not used by crops also leach into lower water levels. Manure has been used for centuries to create a fertile ground for farming. In the Province of Drenthe typical 'Esdorpen' (Foorthuis, 1993) still show in the landscape: the process of using manure on specific places to improve the ground for better crop yields. The nitrates in manure are necessary for crops to grow on the otherwise barren sand grounds of Drenthe. The first farmers in Drenthe where bound by the scarcity of manure produced by the livestock that was available. These limitations have been removed by the introduction of artificial fertilizers and the ability to import animal foods from elsewhere. This led to an increase in livestock and crop cultivation, which led to increase in manure and nutrients on the soil. The abundance of manure and fertilizers on the soil that is not used by crops will leach into ground and surface water via rainfall. In surface water it causes algae blooms and eutrophication. If contaminated ground water is used for drinking water it can cause illness (Lægreid, et al. 1999; Hester, et al. 1996).

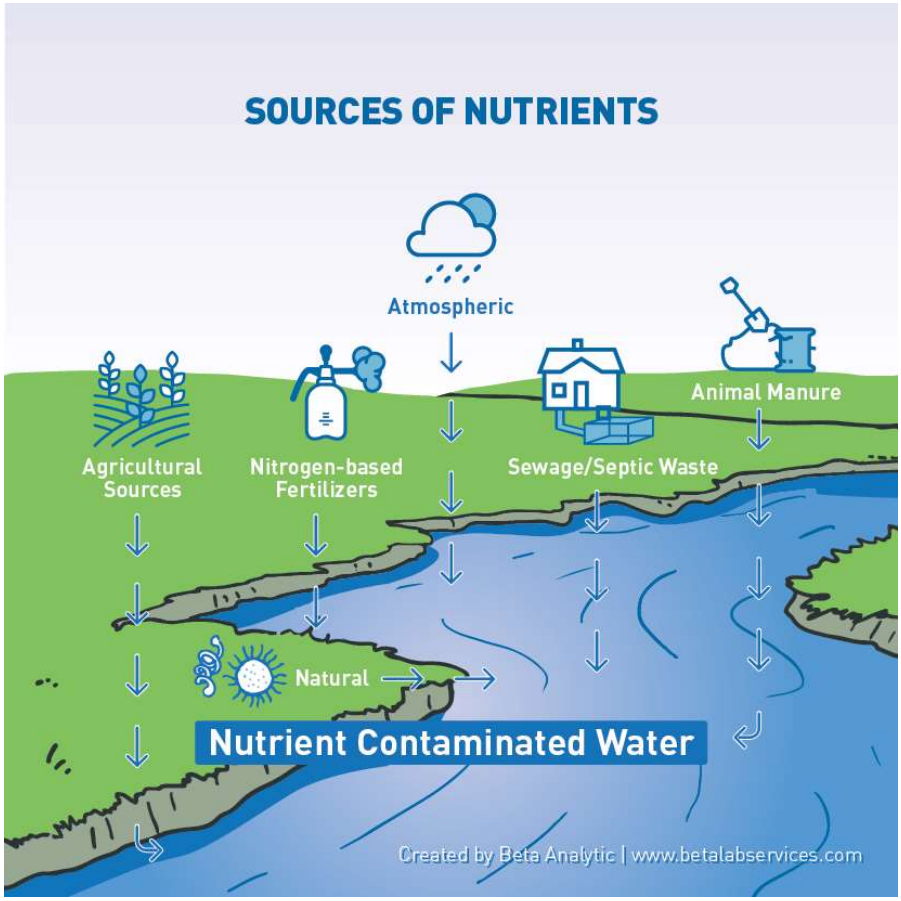


Figure 5 Sources of nutrients Photo: https://www.betalabservices.com/nitrates-in-water/

Besides manure and artificial fertilizers also plant / crop parts left after harvest that decompose can leach nutrients, as well as atmospheric diffusion and natural decomposition of organic sources. Sewage and septic waste can be a source of nutrients as well if it isn't threated in a sewage plantation. Although all of these play a role in the total deposition of nitrates into the ground water the amount differs. The largest influence is from manure and fertilizers that are not used by crops (Straatman, 1989). Crops therefore influence the amount of nitrate deposition to a large amount. Thereby water quantity influences water quality, because crops grow less during a drought or can fail completely thereby leaving nutrients in the soil. This problem increases if farmers are not able to irrigate the crops during the dryer periods (Pedersen, et al. 2009; Hansen, et al. 2015). Different types of crops influence the nitrate retention as well, grass and corn for example have different nitrate retentions. Catch crops or winter crops are planted in autumn and can trap surplus nitrogen in the rootzones. Common catch crops are ryegrass and brassica (Pedersen, et al. 2009; Meisinger, et al. 1991). This way the choice of planting different types of crops can influence the total level of nitrate leaching into the groundwater levels.

Health impacts from nitrate in drinking water can occur from the current levels as the requirement of 50mg/L is higher than the no-effect level of 25mg/L which occur in 3,5% of the supplied drinking water (Van Grinsven, et al. 2016). van Grinsven, et al. (2010) claim a total of 100 cases of colon cancer could be the result of high levels of nitrate in drinking water, this relates to 1% of the colon cancer cases in the Netherlands.

Spatial dimensions

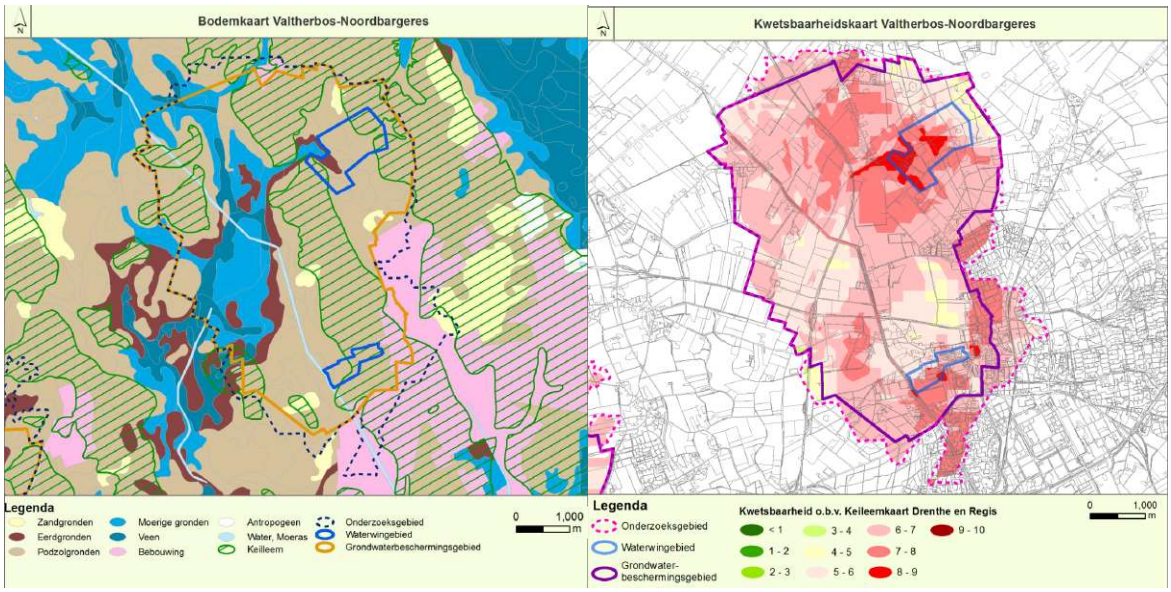


Figure 6 map of soil type in the area (source BRO via (de Vries, et al. 2019)

Figure 7 vulnerability map area, red areas are vulnerable water retention areas (source de Vries et al., 2019)

The vulnerability of an area is determined by hydrological (travel time of water in ground) and hydro chemical processes (decomposition of toxic elements). Three different types of aquifers are phreatic, semi-confined and confined. Confined aquifers are protected by a layer of clay and loam which separate the lower underground aquifer from the pollutants from the top. Phreatic aquifers do not have any protection from such a layer and can be directly contaminated from pollutants leaching into the ground. The area of Valtherbos-Noordbargeres is classified as a vulnerable area (de Vries, Steinweg, Krikken, & Holsteijn, 2019). The travel time for water is relatively fast towards the wells, around 60% of the water travels less than 100 years between precipitation and extraction. Besides hydrological vulnerability the area is also vulnerable in a hydro chemical sense, the area has an irregular and thin clay and loam confining layer between the phreatic and two lower water carrying layers. This layer is not optimal for containing pollutants in the top layer. The soil type in the top layer is also not optimal for removing pollutants, nitrates and organic microcontaminants adhere to organic materials. However, the area contains parts with sandy soils with low organic material, these areas will not be able to retain as much nitrates as other soils. Vulnerability caused by a combination of low nitrate retention in the top soil, low resistance of the covering clay and loam layers, and the fast precipitation towards the wells creates high vulnerabilities which is visualized in figure 4.
Besides natural dimensions, a man-made dimension also influences the vulnerability of this area. The channel “Oranjekanaal” creates an inflow of water though precipitation and in dry periods is also used for supplementation of water on the west side of the area. This water is from the IJssel lake and has a different chemical consistency and can contain pollutants.

2.2 water governance structure

How is the governance on water structured? (question 2)

European

Water quality regulation is the basis of nearly all national policies to reduce nutrients leaching into the environment. Sectoral policies of the 1980s and of 1990 were based around specific problems relating to specific sources; this technocratic approach reduced complexity and the complexity of dealing with multiple stakeholders. Sectoral policies however face the risk of becoming less effective. In 1991 the European commission introduced the nitrates directive, which focussed on the nitrate excess of agricultural practices polluting water sources. A more complete directive started in 2000 with the introduction of the Water Framework Directive (WFD) which required national governments to implement river basin management plans in 2009. The goal of the WFD is for all waters to gain a good ecological status which is based on chemical, flora and fauna found within the water. The WFD relates to the nitrate directive especially with the introduction of the groundwater directive of 2006. Nitrates and phosphorus have proven to be a limiting factor for these bodies of water (Van Grinsven, et al. 2016). The European WFD is implemented as the 'Kader Richtlijn Water' in the Netherlands. The figure below (figure 8) shows the influence of directives and the overlap they have in order to achieve the common goal of better health and welfare across the European union. The National Emission Directive (NECD) is not directly related towards water quality and quantity but with air quality and therefore not further mentioned in this research.

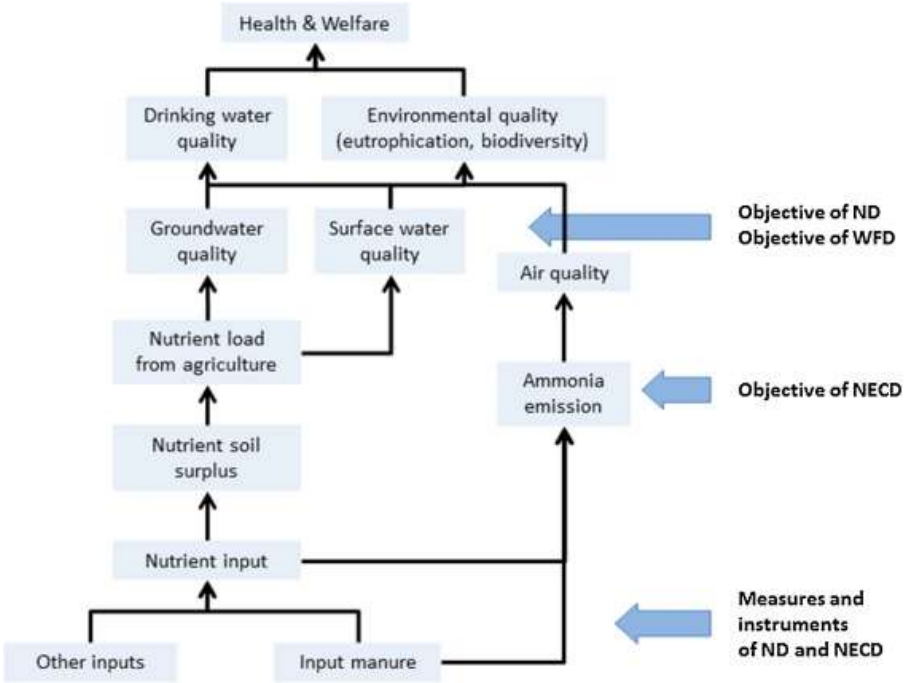


Figure 8 Hierarchy of indicators for the objectives and goals of the different Directives (source van Grinsven, et al. 2016)

National

Dutch legislation has been actively reducing the environmental stress of manure since 1984 and has implemented the nitrate directive since 1992 in the manure and fertiliser act. The nitrate directive allows for a derogation if the extra manure does not conflict with the targets for maximum nitrate and other chemical levels. Dutch derogation allows a manure level of 230kg/ha on dairy farms on sandy or loess soils, with 80% grassland after a reduction from 250kg/ha in 2015. The early 1990's meant the introduction of MINAS (Schröder & Neeteson, 2008) (mineral accounting system) which introduced a farm to farm goal-oriented approach to reduce mineral excess. This approach gave the farmer the ability to take measures as he/she saw fit as long as the resulting excess was within the legislative

requirements. The European Court declared the system of MINAS as a part of 'the Netherlands action programme' not in compliance with the EU nitrate directive (Van Grinsven, et al. 2005). After this the Dutch government had to adapt the legislation to match the means-oriented requirements of the European legislation. The new programmatic approach however immediately came under scrutiny for legal and practical implementation reasons (Sanden & Leroy, 2014; Schoukens, 2019; van den Burg, A. B., 2019; WÖSTEN, 2011).
The national government does implement some of this legislation into practice via the national executive organisation 'Rijkswaterstaat', this is however limited to the national lakes (IJsselmeer), important waterways and the North Sea. The groundwater in the case of this research is not part of the responsibility of 'Rijkswaterstaat'.

Regional

On the regional level the Provinces implement the national legislation into practical application. The Province is responsible for the ground water, where water boards are responsible for flood defence, surface water quality and water quantity, municipalities take care of sewage and stormwater facilities. Drinking water companies' only responsibility is drinking water (Woltjer & Al, 2007). Drinking water companies extract water from retention areas. These areas are divided in different zones, based on the time water requires to flow. The direct area of extraction has stricter regulation, whereas zones further away can be used for farming and even urban areas are possible. These areas do have more restrictions than areas outside the protected zones. The figure below (figure 9) by Woltjer & al (2007) indicate the separate responsibilities of the different levels of government. However, these different levels of government are still linked to each other and nearly all legislation is a trickle down from the water framework directive.

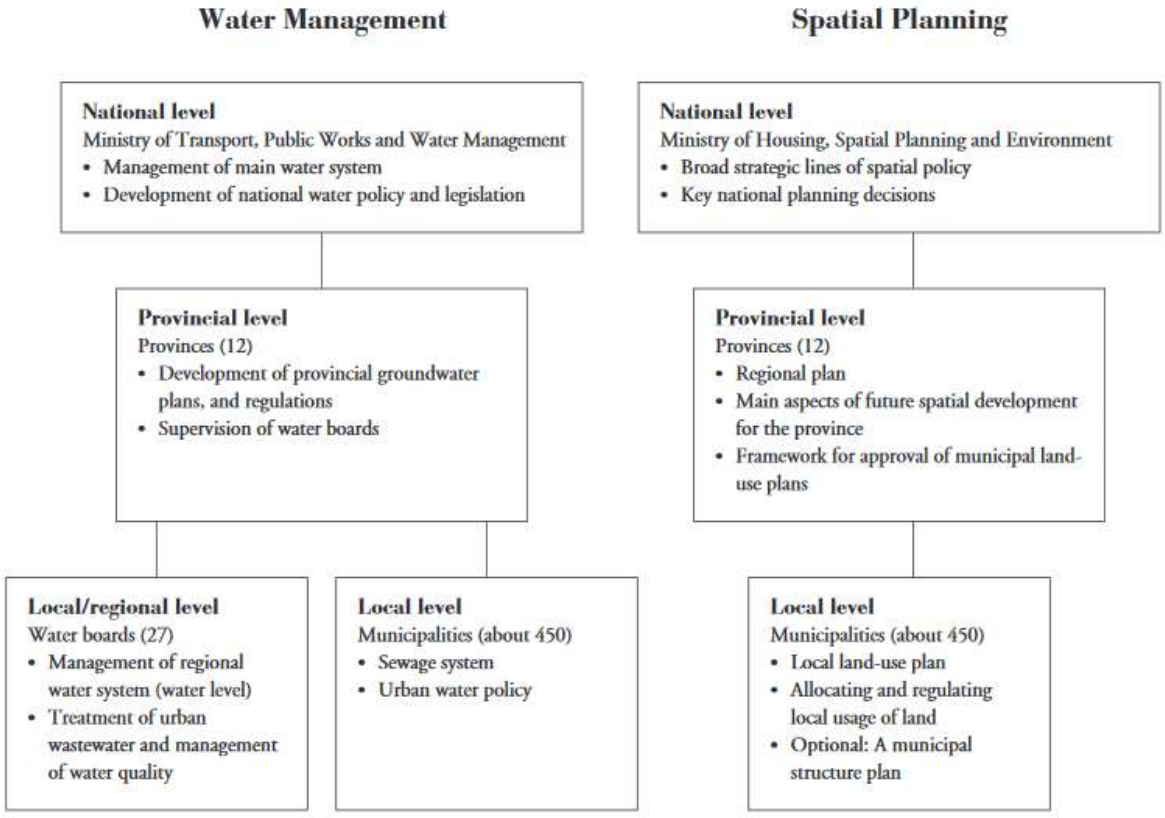


Figure 9 responsibilities in the current Dutch water management and spatial planning systems (source: (Woltjer & Al, 2007)

2.3 co-creation

What is co-creation, and how can it influence willingness of farmers to adapt? (Question 5)

Defining co-creation

Co-creation in agroecology is often academically discussed as a bottom up and participatory approach where scientists and farmers cooperate and stimulate each other in gathering knowledge and use their different perspectives and specific knowledge in filling missing gaps (Gliessman, 2018; Milgroom, et al. 2016; Ramaswamy & Ozcan, 2018). Co-creation can however include more actors than farmers and scientists, and is not limited to agroecology as well. Within this research co-creation is described as a communicative form of spatial planning where the different stakeholders including governments work together to increase the total knowledge and willingness to improve water quality and quantity problems. This description resembles the older general definition of Ostrom (1996, P.1073*) "a process through which inputs from individuals who are not 'in' the same organization are transformed into goods and services".* Ostrom saw co-production as a way a gap between government and its citizens and success would encourage citizens to create more horizontal relationships and social capital. Success with one government entity would stimulate citizens to also approach other entities to increase the quality of service of multiple government agencies.

Developments in communicative planning

Decentralization has brought a rise in communicative planning: no longer is top-down planning suitable for every problem. European subsidiarity regulations have stimulated the trickle down of policies from the national to regional or even local responsibility. The dynamics of policy making changed from a strict rational, where every problem was solvable, into the complex and dilemma filled reality of life (Voogd, 2001). Voogd & Woltjer (1999) show the era of technocratic instrumentalism has past and although communicative planning poses certain threads, with care and deliberate choices these can be mitigated. Ostrom saw co-production in an ideal setting where the relationships between actors was equal, open and without restrictions. As Flyvberg (1998) shows, these relationships are seldom in perfect balance. Governments have a legal power which citizens do not have, and money, knowledge, time and influence all play a role in changing relationship dynamics. Fraud and corruption might even come into play, and destabilize the entire situation. Does this mean co-creation is an unattainable utopia? Fortunately, this is not the case. Regeer & Bunders (2009) for example show that the potential for knowledge co-creation still exists as long as a common goal can be expressed and can be beneficial in many situations.

Stakeholders

Stakeholder identification is needed for communicative planning. This differs from the top-down approach based on the limited scope of the technocratic approach of the past. The technocratic approach had little to no room for input from local sources and relied instead on the knowledge of policymakers, companies and institutes such as engineering firms and universities. Sometimes stakeholders will take initiative by themselves in making contact with governments. However, this will not be the case for all problems, and will generally focus on the visible problems directly affecting the stakeholder. Ground water pollution via nitrates is not a visible problem on the surface for farmers, the grass will still grow, maybe even better than without a nitrate surplus. To participate in co-creation the ability and willingness of stakeholders is needed. Ostrom's (1996) process of co-creation requires an input from all stakeholders in order to generate new and improved knowledge and options.

Finding stakeholders for the process of co-creation requires investigation of the initiator. The initiator needs to actively search for partners to co-create with. A method for finding stakeholders can be actor-mapping. Hereby the initiator starts to analyse who matters and why they matter (Fottler, et al. 1989). Brugha & Varvasovszky (2000) elaborate on this and suggest to give a visual representation of the strength of relationships and possibilities for coalitions between stakeholders.

Influence on willingness and ability to adapt

As Albrechts (2003 p.906) argues *'planning processes must make a contribution not only to substantiating these changes but also to mobilising the social forces necessary to fulfil the proposed policies'.* The planning approach used in solving a societal problem influences the response and willingness. Co-creation is used to engage stakeholders into active participation. This participation is based on aligning priorities and interests and aims to create a common strategy. Different starting positions in a discussion can create tensions which disrupt the common interest and can negatively impact the willingness to participate. The process of gaining willingness is not straightforward but relies on the process of dialogue which should be structured carefully to generate a common base on which can be expanded. The introduction of two or more opposite views as a starting position can stop the co-creation process before it has started (Susskind, et al. 1999). Susskind et al. provide a set of requirements that needs to be met before consensus building within a group works best. Co-creation requires this consensus as this is wat motivates the stakeholders towards a common interest. The set of requirements is: objective facilitation, time, ground rules and a clear route map of the process. Bekkers et al. (2014) state the importance of manoeuvring space and flexibility to change. Strict regulation, requirements or frameworks can be counterproductive for co-creation. Flexibility of regulation instead can create abilities for change, for example by changing regulation to fit new ideas or removing bureaucratic hurdles.

Barriers in co-creation

Through decentralization and communicative planning, the amount and roles of stakeholders has changed drastically (Voogd & Woltjer, 1999). Mannberg & Wihlborg (2008) argue that active and participation citizens are favoured within communicative planning. It is clear that co-creation suffers from this statement as well: non-active citizens have less influence in comparison with active citizens. The participation of all stakeholders can be seen as the legitimizing of the used method: if a large portion of stakeholders lack within the communicative planning process it loses its democratic powers. The process of co-creation contains barriers as well, for example power imbalances (Flyvbjerg, 1998) can create a barrier for stakeholders to participate. The power imbalance might make stakeholders reluctant to share (private) information. Fainstein (2000) questions the Habermasian assumption that reasonability of people can solve all conflicts. Instead she poses a vision which relates more towards Flyvberg and forester where weak stakeholders cannot win, or if they do win it is more a symbolic victory and not a result of achieving consensus between the stakeholders.

2.4 sustainable agricultural practices

What are 'sustainable agricultural practices', and how can these practices benefit groundwater quality? (question 10)

Defining sustainable agricultural practices

Sustainable agricultural practices are described differently in the academic literature (D'souza, et al. 1993; Francis & Porter, 2011; Kumazawa, 2002; Rodriguez, et al. 2009; Wezel et al., 2014), however they have a common ground in environmental improvement, economic feasibility and social sustainability. Without any of these parts the implementation of an agricultural practice will fail or will not improve the current situation. This research focusses on the relationship between ground water and agricultural practices and defines a sustainable agricultural practice as follows: '*any practices that improves the quality or quantity of ground water without a (significant) degradation or improvement towards the economic and social stability of the system'*. This definition does not speak of resource availability (Eisler et al., 2014; Thompson & Nardone, 1999; van Veen, 1999) as the Dutch production of food is already exciding the requirements for local sufficiency and local population is not expected to grow in any way that negates this excess.

Livestock & crop cultivation

The area of south east Drenthe has both a large live stock (cows) and crop cultivation. Livestock production produces manure which can be used to fertilize the crops. However, the excess manure of intensive livestock cultivation requires a minimum amount of space. Lower amounts of manure on larger areas lowers the amount of nitrates leaching into the ground water (Gordon, et al. 2010; Sakadevan, et al. 2017; Sakadevan, et al. 2015; O'geen et al., 2010). Conventional intensive agriculture has a high number of livestock per area, sustainable agriculture practices such as for example a biological dairy farm decrease the number of cows in order to mitigate the strain of manure on the area. The biological farm does receive a small bonus in milk price, however the current market for biological products is not large enough for all farmers to transform to biological as more land per cow can increase costs. Crop cultivation use manure as fertilizer, however synthetic fertilizers can also be used. The balance between fertilizer deposition and crop uptake determines a large factor of nitrate leaching. As Sakadevan, et al. (2015) state, the efficiency of nitrogen and phosphorus fertilizers around the globe have proven to be low. Use of catch crops, and favouring polycultures with both plants instead of monocultures can increase the efficiency of nitrate retention. Correct timing of ploughing and the use of sensor data with specific local manure deposition can increase the nitrate retention even further (Di & Cameron, 2002).

Barriers for sustainable farming

Most academic literature of sustainable farming centres on broad knowledge without any specifics on measures. Moreover, a large part of the scientific literature of sustainable agriculture focusses on enlarging agricultural practices to feed more people. This would be the exact opposite of the goal of this thesis which focusses on lessening the effects of farming instead of increasing.

Sustainable farming in an ideal world should be perfect, however reality is not. Sustainable agriculture is a balance between economics, ecological and social factors. Economical barriers relate to investments for implementing new practices, materials or equipment, but also the risk of reducing productivity, and the addition of extra labour costs (Rodriguez, et al. 2009). Even proven concepts that do not decrease profitability and are as viable or better as conventional agricultural practices can be perceived as a risk to profitability. A period of transition and cost for changing equipment and high up-front cost might not weigh up to an ‘uncertain’ profit in the future. Current financial situations and constraints from banks in supporting new and unproven methods are a barrier as well. A lack of subsidy when implementing extensive farming methods could also discourage potential farmers. Besides financial constraints several other factors also create barriers, firstly the spatial setting. Sustainable agricultural practices should be place based, pineapple plantation practices is not relevant for farmers in a cold northern country. Secondly the complexity involved with new methods can be a barrier. The use of sensor data to apply manure in different amounts at a specific point is a complex method that requires knowledge that is not common among farmers. Thirdly long periods of testing and proving new methods can scare farmers. Trials can take several years when testing different methods and farmers may have to wait a year between each crop cycle. Fourthly the regulation might hamper new methods, as new pesticides or gen modified crops may need approval of the relevant authorities. Also new equipment such as remote-controlled drones need the appropriate permissions and could require governments to change legislation in order to be implemented (D'souza, Cyphers, & Phipps, 1993; Francis & Porter, 2011; Kumazawa, 2002; Rodriguez, Molnar, Fazio, Sydnor, & Lowe, 2009; Wezel et al., 2014).

2.5 synthesis and conceptual model

The generation of willingness and capability is crucial for the implementation of sustainable agricultural practices. Only when the farming community embraces these practices as the new paradigm can structural improvement in ground water quality and quantity be expected. Figure 10 is the conceptual model build to visualise the theory of this research. Farmers and water sector should work together as they are mutually depended on the other, yet the differences in interest should not be excluded. Instead these should be taking into account when working together, applying knowledge, experience, resources, influence, power and active participation. The ideal speech from Habermas where all speech is pure, balanced and without other intentions will not be attainable in real life, but during the process of co-creation it is important to strive for this, as untruths, personal gain, and power imbalance will disrupt the process. When applied in the correct manner and with active participation from both sides, co-creation will stimulate the willingness and capabilities of both the farmers as well as the stakeholders in the water sector. Increased willingness and capabilities can then be translated into a paradigm shift where farmers would be more likely to choose sustainable agricultural practices over conventional practices.

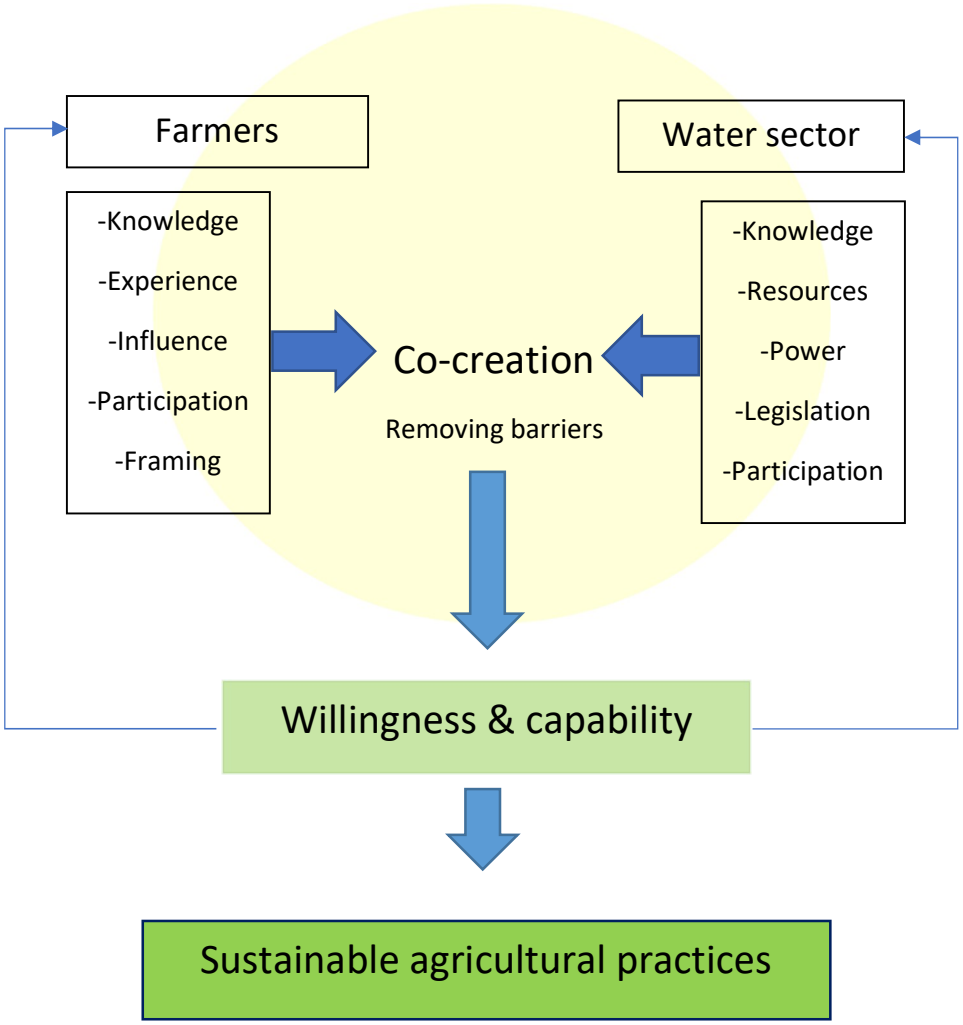


Figure 10 conceptual model (author, 2020)

3 Methodology

A researcher is required to make deliberate choices in defining the type of (case) study, the logic of research design, data collection techniques, approaches to data analysis, interpretation and reporting (Yin, 2003). Chapter 3 describes and explains the choices made in the methods of this research, the first part explains the choice for a case study approach, the second part defines the spatial and time boundaries of the data collection, the third part shows the process and choices of selecting stakeholders, the fourth part explains the interviews.

3.1 Case study

A case study is often used as an approach to gather in depth knowledge about a specific phenomenon. The term case study is also quite loosely defined in the literature (Punch, 2013). Clifford et al. (2016) state that case studies are useful for in depth analysis of a phenomenon in its natural setting. The choice of which research type to used is based on the knowledge that is needed to answer the research question. The research question that is asked in this thesis is:

"How can co-creation support willingness and capability for farmers to take the lead in sustainable agricultural practices improving water quality and quantity in South east Drenthe?"

This question is answered in the local setting and is ideally suited for an in-depth case study approach. It requires knowledge about individuals and the depth in which this knowledge is needed influences the methods used to gather this knowledge. In-depth knowledge is best suited with a qualitative approach such as an interview instead of more superficial methods. This can reveal deeper meanings and motives in the participants than a questionnaire with preformulated answers for example can.
A case study is also useful in this research since it does not focus on a single truth, instead a case study is about the holistic interpretation of all data as a complex system (Yin, 2003). This also enables the analysis of the small scale of the area and number of participants, for there are not enough subjects in the area to use large scale quantitative analysis.
External influences restricted research methods further, the corona virus epidemic restricted the interactions with participants. Meetings, groups sessions and other research methods which involved physical contact were no longer viable. The timing of the corona virus was unfortunate as the restrictions started at the start of the data gathering, this meant changes in the research method were needed, and participating in a group session was no longer possible.
In conclusion this method was deemed the most appropriate to investigate and analyse the complex situation of a locally specific problem, where in-depth knowledge is more important than large statistical generalization.

3.2 Spatial and time boundaries

The unit of analyses, or the case, is determined by defining spatial boundary, theoretical scope, and timeframe (Yin,2003). The spatial boundary of this thesis is based on the ground water protection area of Valtherbos-Noordbargeres. This area is smaller than the south east of Drenthe, however it is one of the four drinking water extraction areas in that area. Due to the small scale of the research it is deemed better to analyse one area deeply than four areas superficially. The area was chosen for the unique spatial properties of vulnerability and high nitrate levels as has been explained in chapter .

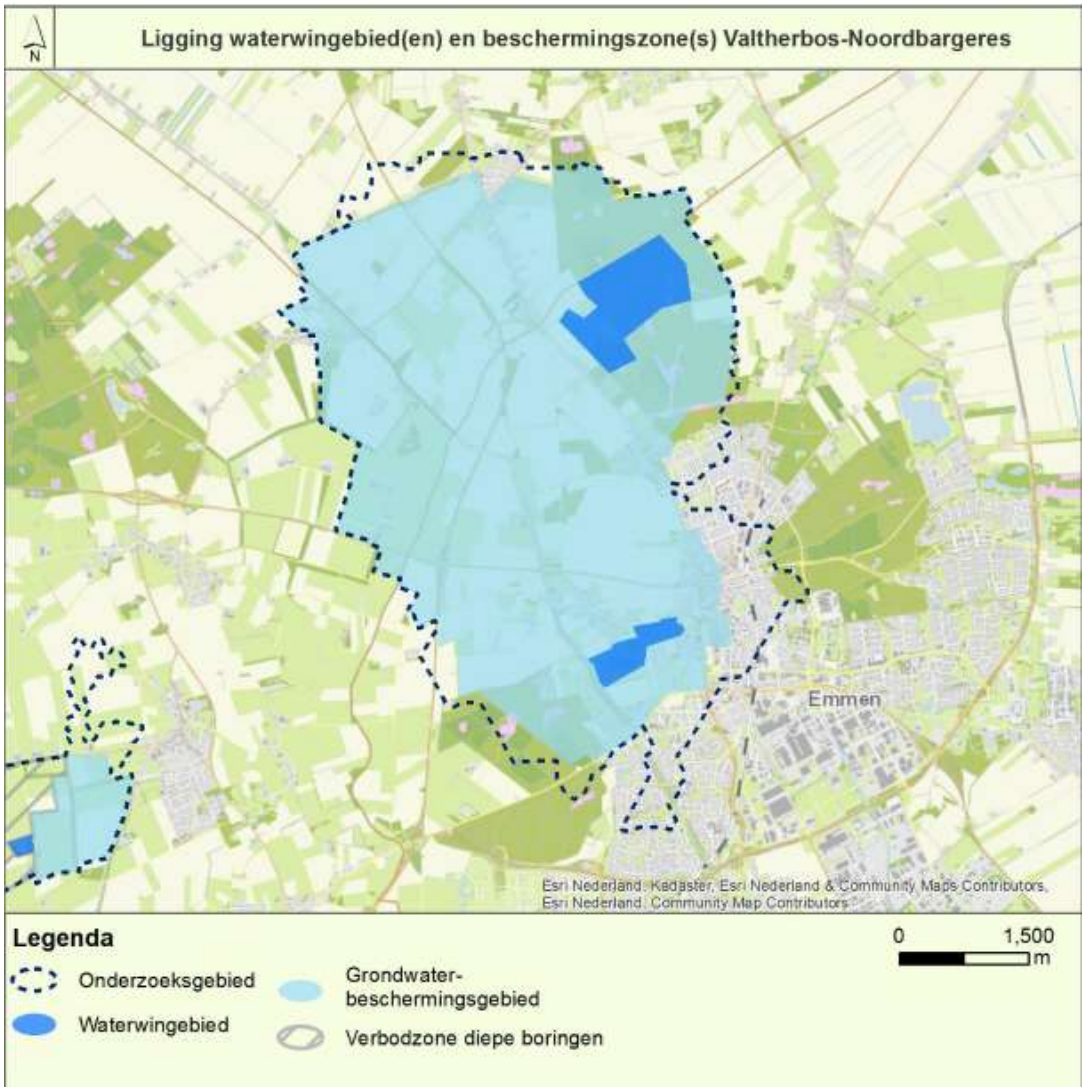


Figure 11 area of investigation Valtherbos-Noordbargeres. modified from (de Vries, et al. 2019)

The theoretical scope of the research is based on the theory of chapter 2. The timeframe of the research is based on the schedule of the university: the first preliminary meetings took place in February and the research needs to be finished at the 10th of July. The research focusses on the current situation and how it can be improved in the future. In the interviews the personal history of participants is used to illustrate effects and reasons behind the current situation.

3.3 The case of Valtherbos-Noordbargeres

The area of Valtherbos-Noordbargeres is a groundwater protection area in the south east of Drenthe. Since 1937 water extraction started in Noordbargeres, Valtherbos is operational since 1965. The extraction sites are close together, therefor the area is seen as one, with a shared protection area. It is an important area for the supply of drinking water to the south east of Drenthe including the large city of Emmen. The extraction of 11.5 million cubic meters of water for both extraction sites combined is permitted. The average extraction in the period 1989-2017 has been 9.7 million cubic meters of water.

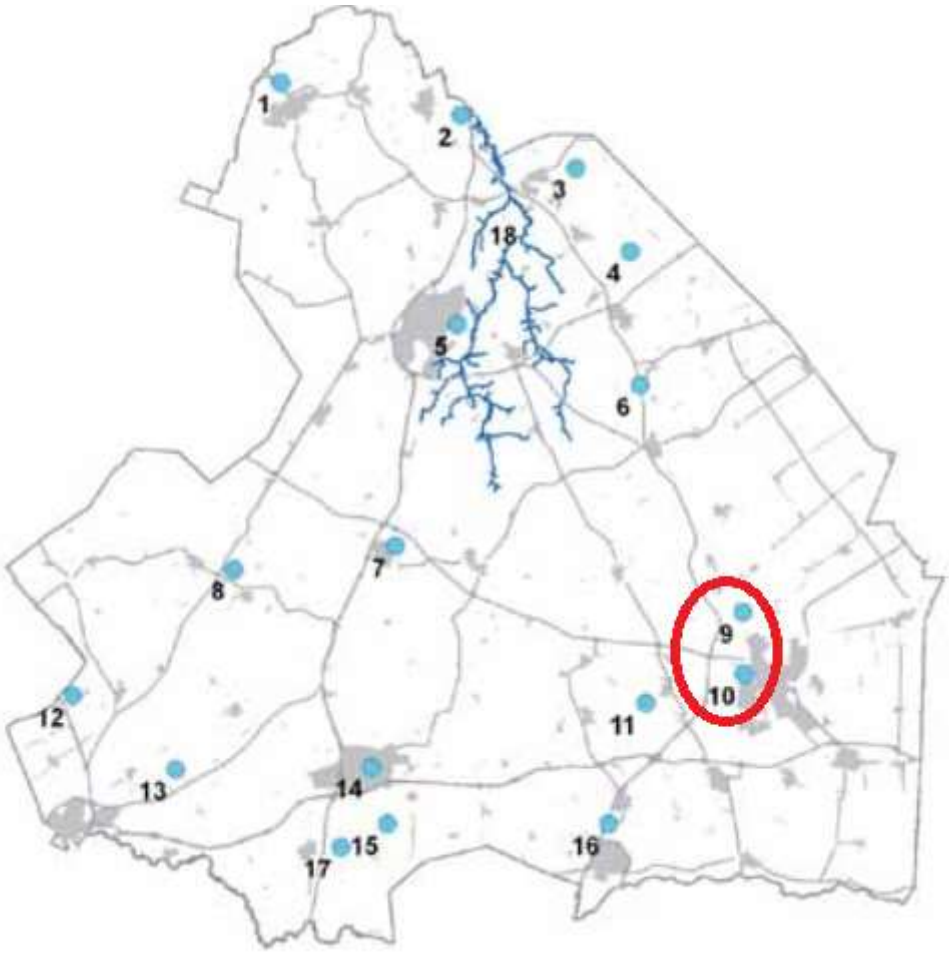


Figure 12 groundwater protection areas in Drenthe, Valtherbos-Noordbargeres circled (modified; van den Brink, et al. n.d.)

Relevance of the area Valtherbos-Noordbargeres as a case

The area of Valtherbos-Noordbargeres has been selected as a relevant case for four reasons. The current exceedance of nitrate levels, the large influence of agriculture in the area, the importance of groundwater extraction for the surrounding area, and the existing project groups between farmers and the water sector. The combination of these factors made this area the best candidate. Other areas in south east Drenthe have been considered, however the inclusion of extra areas is not expected to be of significant benefit for this research. The research focusses on the interactions between farmers and the water sector whereby the spatial differences are of less importance.

Both agriculture and water are important for this area. Agriculture is the largest user of land and the main economical drive in the area, whilst the water is necessary to supply a large part of Drenthe with clean drinking water. Tensions between agriculture and the water sector are not new in this area. Already in 1987, the municipality extended the protection area from a 10-year zone to a 25 year zone as a first in the Netherlands. Already at this point in time there was a division of interests between the water sector and the agricultural sector visible. The extension of the zone was the result of a highted concentration of 1,2-chloropropane in the extracted water.
In order to keep both drinking water production and agriculture viable in the future in this area new methods and a collaboration between the water sector and agricultural sector is required. In order to work together it is important to establish the different stakeholders and their position on ground water quality and quantity problems.

3.4 Selecting interviewees

Selecting interviewees requires knowledge about the stakeholders. In chapter 2 the governance of the water sector was analysed. This analysis indicated that the Province and the water company are the main stakeholders of the water sector in combination with groundwater problems. An exploratory meeting with WMD was held to get an indication of the current situation and to find other relevant stakeholders. The current project groups for farmers in the area were indicated as the best source for interviewees as they are familiar with the current situation on groundwater. The Province and the consultancy firms 'DLV advise' and 'HLB' were indicated as important partners. WMD was expected to be a gatekeeper in reaching other stakeholders. This has been true for some part. The regulations on privacy makes sharing personal information such as contact information more difficult; instead it was proposed by the water company that the researcher would visit a meeting of the project group where farmers would be present. These meetings were held a few times per year and one would follow soon after the preliminary meeting.
The meeting however was cancelled due to the arrival of the Corona virus in the Netherlands. This resulted in problems in reaching potential interviewees, which was solved by using a local resident as guide and driving around the area and stopping at farms to either leave a message asking to contact the researcher if they were willing to participate in the research or by directly speaking to the residents. This was done during the morning and afternoon which is a time period when almost all farmers are working at their farms, the day was also warm and sunny which might have helped in getting the farmers at ease instead of visiting late in the evening when it is already dark outside. The influence of corona however might have resulted in an unwillingness to participate with an unfamiliar person. The response on the left messages in mailboxes was zero. After the first day of finding participants the direct contact of farmers was no longer allowed according to university rules. And only messages in mailboxes were left, with no response. Both (dairy) livestock farmers and crop cultivation are present, as well as a biological dairy farmer.

Table 1 Interview codes and dates farmers

	Interview code	Date	Role
Farmer 1	F1C	30-03-2020	Crop cultivation
Farmer 2	F2DB	30-03-2020 & 30-07-2020	Biological Dairy farmer
Farmer 3	F3D	02-04-2020 & 31-07-2020	Dairy farmer
Farmer 4	F4D	03-04-2020	Dairy farmer

The connections with the consultancy firm DLV advise, the Province of Drenthe and the water compony WMD were made using the contact information on their sites and internally they suggested the correct person for participating in the research. The waterboard 'Vechtstromen' was also contacted and was able to give a short response, however the waterboard is not responsible for the groundwater quality and quantity problem, they are only responsible in relation to surface water quantity and quality.

Table 2 Interview codes and dates water sector

	Interview code	Date	Role
Province of Drenthe	Prov	15-06-2020 & 06-08-2020	Policy officer water
WMD	WMD	17-06-2020	Area manager agriculture
WMD	WMD2	03-07-2020	Strategic program manager
DLV advies	DLV	09-06-2020	Project leader execution
Waterboard 'Vechtstromen'	--	--	Not relevant, therefore excluded

3.5 Semi structured interviews

To interview farmers and stakeholders semi structured interviews were used. A different set of interview questions was made for the farmers and the water sector since they have different roles within this context. The use of semi structured interview allows a level of basic comparability between the participants with every participant receiving the same questions. Semi structured interviewing allows the researcher the freedom to add questions during the interview to gain a better understanding, as well as allow for inductive knowledge to be expanded on. For example, a question about willingness can be followed up with more in depth questions to find the underlying meaning behind an answer.

A second reason why interviews are useful is the ability to gather information about the past as well as the current situation simultaneously. It should be noted however that memories of participants especially from a long time ago might not be very accurate, feelings and motives with regard to the past might not be well remembered. Interaction between the interviewer and interviewee can help the process of memory recollection, however this is made more difficult since the lack of physical contact restricts the non-verbal communication as well as it distorts the nuances through limitations of audio quality with telephone communications (Norrick, 2005).

A third reason for conducting interviews is that they are useful within a relatively small timeframe of data gathering. Interviews only require a single appointment with each participant and the appointment itself is also limited in time. The interviews where held in such a way that the participant would feel most at ease. The original idea was to use a neutral place such as a café, or if the participants would prefer at their homes for farmers, or their offices for the Province, water company or consultancy. Due to the corona virus this idea was abandoned and instead all interviews were held via the telephone. Other options such as skype where considered however the ease of recording via telephone and the fact that not all participants used skype made this the better solution. It should however be stated that face to face interviews would have been preferred over any digital method, this would allow a more immersive interview were non-verbal communication would have added to the data gathering process. Interviewing farmers does require a flexibility on the part of the researcher as some interviews had to be postponed due to work on the farm; also, the timeslots of the interviews where mostly in the evening as this was preferred by the farmers.

Data protection and ethics

Ethics have always been an important aspect in research, fair treatment of participants, but also objectiveness of the researcher play a role in the credibility of the research. Several choices have been made to ensure the best ethical and objectivity possible. First the area chosen is not related to the researcher, with no personal stake or interest in the area. Interview questions have been made in a neutral and open wording. The personal opinions of interviewer were not expressed during any of the interviews to not influence the participants.
All participants either gave written or verbal permission to use the interview in this research, they were notified that they could withdraw their participation in the interview for a period of 14 days. A reference letter of consent is presented in appendix 3.
Participants have been asked if they agree with the use of their roles in the report. Although this might lead to identification of stakeholders it is not expected to negatively influence the personal of professional life of the participants, all participants agreed to the publication of their roles. Names and other personal information have been excluded for the report as this does not benefit the research and ensures a level of anonymity for the participants.

Data protection has become far more important in recent years with increases in privacy regulation, the raw data includes private information about the participants. The researcher has a responsibility to protect the data of the participants as best as he can. This is done by not sharing any raw data with third parties, and using adequate protection against digital and physical media theft. The data are stored on a password protected computer and backups physical data (papers etc) are stored behind locked doors. At the finish of the research raw data containing any personal information will be deleted / destroyed to avoid any chance of damaging the privacy of the participants.

3.6 Coding, analysis and interpretation

Transcripts of the interviews in themselves do not provide answers to the research questions. A form of analysis is needed to structure and compare statements between participants. This analysis is based on codes which in turn have been based on the research questions and the theoretical section. Coding is used to analyse transcripts and translate this into credible data. Coding helps to organize the data so that patterns, categories, similarities, differences, associations and relationships are made visual (Clifford, et al. 2016). This organization makes it possible to analyse and draw conclusions from the different interviews since they are linked via the coding on the relevant parts.
Coding requires multiple steps, the first is selecting the relevant parts, this is done with the indicators. The second step is the first round of coding of the relevant parts, this makes it possible to organize between the different interviews. The first coding round is often descriptive and shows simple patterns. As a third step, a second round of coding can be used to apply a more analytic view. Dependent on the type of research, and type of required answers the amount of coding rounds can be increased. Coding is also not a straight start to finish process but asks iterations and the researcher has to move back and forward between interviews and even between rounds of coding. A first round of coding was done using the following topics to identify the relevant parts of the interview:

- Which qualitative and quantitative water problems are mentioned?
- Which sustainable agricultural practices are mentioned?
- What are motivations of farmers to take sustainable agricultural measures?
- What is the willingness of farmers?
- What are the abilities of farmers?
- How do stakeholders frame nitrate pollution of ground waste?
- Which options for stimulation sustainable agricultural practices are proposed?

Codes have been applied to the quotes in order to identify categories, similarities, differences, associations and relationships (see appendix 4).

4 Results

Chapter 4 answers the four empirical questions (questions 6 – 9). The first part focusses on the stakeholders and their framing of problems regarding water quality and quantity. The second part explores the willingness of farmers in taking the lead in sustainable agricultural practices. The third part shows the sustainable agricultural practices proposed by farmers. The fourth part reviews the options the water sector has to stimulate farmers into adopting sustainable agricultural methods. All these findings are based on the analysis of the interviews for the area of Valtherbos-Noordbargeres.

The Province of Drenthe and WMD have a project together as part of the 6th NAP. This project has the goal to decrease the nitrate levels to the maximum of 50mg/L in the ground water. A consortium has been contracted to execute this project in several areas in Drenthe including the area of Valtherbos-Noordbargeres. The project provides the basis for analysis in this chapter.

4.1 Stakeholder relationships and framing of water issues

Which stakeholders are part of the water sector in SE Drenthe? (Questions 3)

How do stakeholders frame the problems regarding water quality and quantity in south east Drenthe? (Question 6)

What are the formal and informal relations between stakeholders? *(Question 8)*

This section focusses on the stakeholders of the water sector in south east Drenthe, which stakeholders are relevant, how are they connected to each other, and how do they frame problems regarding water quality and quantity. The first part of this section reviews the different stakeholders and uses an actor map to indicate the formal and informal relationships within the water sector and how they relate to the agricultural sector. The second part of this section focusses on the framing of problems by the different stakeholders. The framing of problems will then be used to analyse commonalities and differences.

Formal roles, relationships, and water legislation

Legal responsibilities and legislation shape the formal roles and positions of stakeholders in the water sector. The Water Framework Directive from the EU functions as the basis for identifying the stakeholders and their formal positions. The EU provides requirements for the national government to implement EU regulation in their national legislation. The EU sets limitations on the allowed level of pollution, but also the amount of manure allowed per acre. These limitations are to ensure the quality of drinking water in the entire European Union.

EU regulation is implemented into national legislation by the national government. The EU and national government provide the legal framework for the local situation in south east Drenthe, they are however not directly involved with executive power. Two decentral institutions are the Province and Waterboards. The Province is tasked with protection of the groundwater quantity and quality, the waterboard has the role to protect surface water quality and quantity. In the case of Valtherbos-Noordbargeres these are the Province of Drenthe, and the Waterboard ‘Vechtstromen’.

The Province of Drenthe is responsible with regard to the protection of groundwater quality and quantity. The implementation of the European and national legislation into policy is carried out via permits, land-use policy and other legal methods. The Province has a responsibility which goes beyond groundwater quality and quantity, and also have to compare these and balance the importance of

measures. They are bound by the legal obligation set in the Water Framework Directive; however, they search for collaboration with other involved parties on the best implementation for the area. A primary goal for the Province is the continuation of safe drinking water extraction in the area.

In the case of drinking water production in Valtherbos-Noordbargeres the role of the waterboard is neglectable since all water production is based on groundwater extraction. Although the Province is responsible for a clean source for this drinking water, this authority is not responsible for the extraction and processing of the drinking water itself. This process is done by the drinking water company 'Water Maatschappij Drenthe' or WMD in short. The relevant water sector in the case of Valtherbos-Noordbargeres therefore consists of two institutions, first the Province of Drenthe, and second the drinking water company WMD.

The agricultural sector in Valtherbos-Noordbargeres does not have a singular formal responsible institution, and includes all individual farmers in the area. Therefore, very farmer itself is a stakeholder in the process of improvements for future water quality and quantity. The agricultural union (LTO) as an interest group is still an important partner to voice concerns of farmers, however they are not a legal representative. Also, not all farmers are member of the LTO. Farmers have a formal responsibility towards their farms to ensure a profitable continuation.

In order to ensure clean drinking water for future generations the Province of Drenthe and WMD have initiated a project in line with the 6th NAP. A consortium has been contracted to execute this program, the consortium is led by "Royal Haskoning DHV", and includes "het Kadaster", "Accountis", "DLV advies" and "HLB".

Informal relations, and interests of stakeholders

Folke et al. (2005) and Pahl-Wostl et al. (2007) claim a necessity to take into account informal roles and relationships as they are beneficial in leaving entrenched positions and openness to change. Informal relationships differ from formal relationships as they are more dynamic, based on personal and perceived factors. They also are not based on any legislative or formal framework making them harder to identify and analyse. The informal roles and relationships have been analysed based on the interviews with stakeholders, and the perceptions of their own roles and the relationships they have.

The Province of Drenthe and WMD have no specific informal role that was identified by the interviews. They are bound by the legislation into a stricter external policy. Internally different informal roles might exist within these organisations, these however have not been examined. The interviews with the farmers indicate differences in the informal roles between individual farmers. Differences in stimulating others to participate and take action are present, as are the interests of the farmers. The biological farmer (F2DB) has a different interest than the other farmers, he does not expect biological farmers to be confronted with additional limitations. The conventional farmers in the area do fear extra pressure and limitations if the required 50mg/L nitrate in ground water is not achieved (F1C, F3D, F4D). Some examples from the interviews:

'I don't have much to do with it, as a biological farmer the amount of manure already is minimal, nitrate levels are very low, I don't expect extra regulation for us.' (F2DB)

'Not everybody is a part of the project, but it's like, guys if we don't fix this together we will get regulation and it will be worse.' (F4D)

Actor map

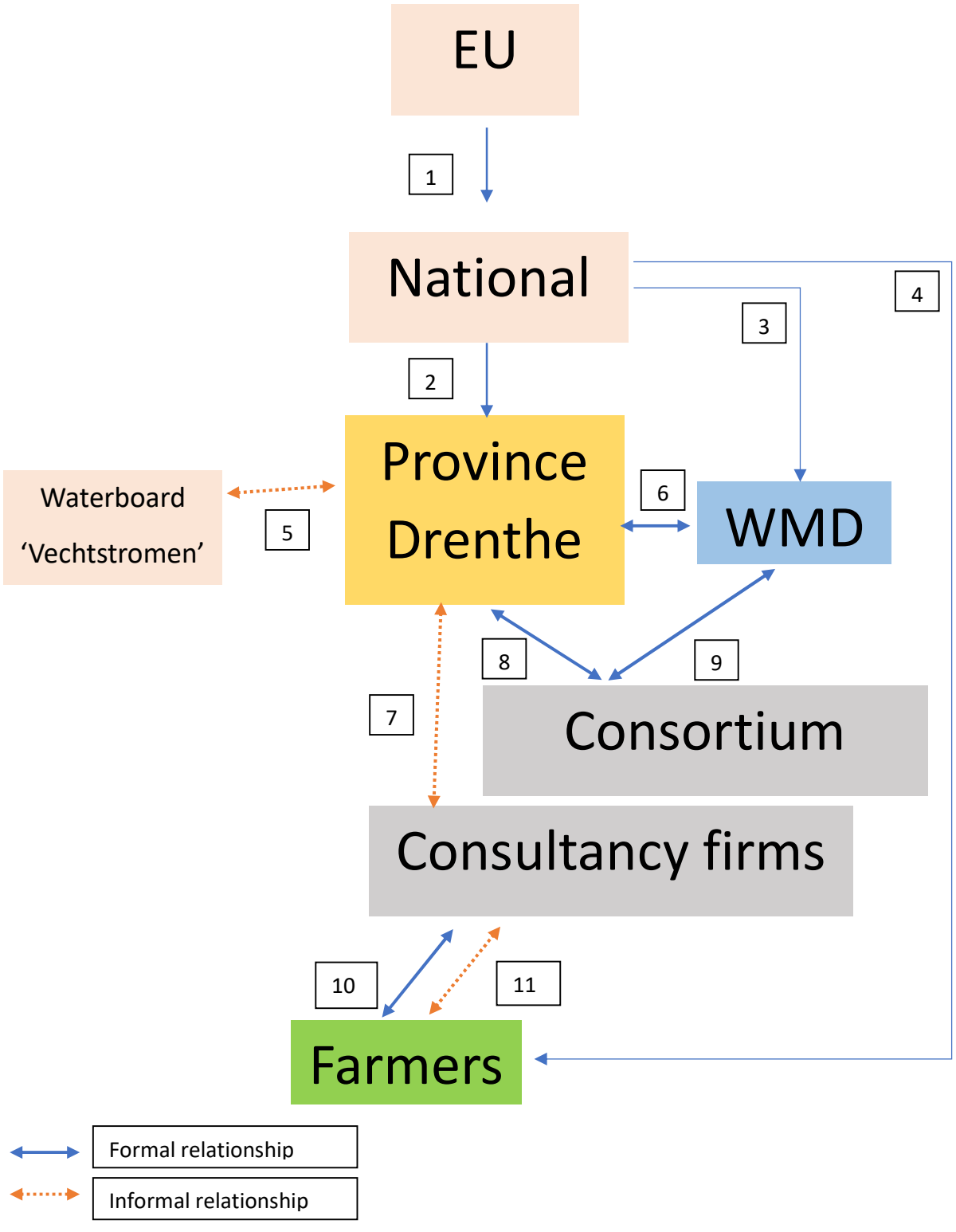


Figure 2 Simplified actor map Valtherbos-Noordbargeres (author, 2020),

Table 3 Description of relationships

	(simplified) description of relationship	source
1	EU provides rules and regulations	Prov
2, 3, 4	National government implements EU regulation into national policies	Prov
5	Province informs Waterboard when appropriate, however no formal connection exist within this project	Prov
6	Province and WMD are partners within this project, strong formal and financial connection	Prov, WMD, DLV
7	Province receives information on local situation and participation, however no formal connection between consultancy firms and Province exists	Prov
8, 9	Consortium led by Royal Haskoning DHV has been contracted to execute the project, strong formal connection	Prov, DLV, WMD
10	Consultancy advisers support farmers in line with the project goals	Prov, DLV, WMD, F1-4
11	Consultancy advisers have been present at the farms for sometimes decades in relation with previous projects and build a personal connection with farmers	DLV, F1-4

Relationships are complex to analyse, informal ones even more than formal. The actor map has been based on the policy documents and legislation analysed in Chapter 2 and the interviews. The actor map depicts a simplified version of reality, omissions have been made for simplification. The consortium is a combination of several organisations such as “accountis” and “het Kadaster”, and is led by “Royal Haskoning DHV”. The consultancy firms (“DLV advise” and “HLB”) are also part of this consortium, however for clarity they have been separated in the actor map. The actor map was made from the viewpoint of the current project groups. Using a different viewpoint, for example flood protection, would result in different relationships between actors, as well as introducing new stakeholders.

The actor map should be seen from top to bottom to understand the hierarchy. On top the EU creates rules and regulation such as the Water Framework directive and nitrate directives. This is pushed to the national government (1) who implements this in national law and regulations. Which in turn is pushed to the Provinces (2), or directly into regulation for the water companies (3) or manure restrictions for farmers (4). These are mainly one-way implementations of rules and regulation and represented by the one-way arrows.

The Province and WMD have a strong formal relationship (6) and are both partners in the regional work group, which is a combined official steering committee and workgroup. WMD and the Province also share a financial connection as they both finance the project. No formal relationship between the Province and the waterboard exist, however the Province informs the waterboard on the progress of the project in a more informal setting (5). The work group of the Province and WMD hired a consortium for the execution of the project and has a strong formal connection (8&9). The Province does not receive individual information on farmers from the consortium, however through informal communications with the consultancy firms the maintain updated on the current participation, motivation and sentiments within the participating farmers group (7).

Farmers have a formal relationship with the consortium by participating in the project (10), as well as maintain a strong informal relationship with the advisors from the consultancy firms (11). Communication between the consortium and farmers almost exclusively goes through the advisors of the consultancy firms.

A final, yet important relationship are the internal relationships within the farming community. Study group meetings, field work, or informal contact between farmers are mentioned by every farmer as important relations.

Co-creation benefits from a strong and stable relationship between stakeholders, however the actor map indicates no direct connection between the Province of Drenthe or WMD and the farming community. Nearly all communication goes through the consortium. This setup limits the possibility for co-creation to individual farms sharing knowledge via the study groups and fieldwork. Larger co-creation on the future of the region as a whole is virtually non-existent, as this would require direct relationships between the Province of Drenthe, WMD and the farming community.

When regarded in the context of the literature several conclusions can be made: the current setup resembles the co-creation in agroecology of Gliessman, (2018); Milgroom, et al. (2016); Ramaswamy & Ozcan, (2018) whereby scientific knowledge (advisory) and agricultural knowledge (farmers) are combined and used to improve the knowledge, ecological impact and efficiency of the farmers. The Province of Drenthe and WMD actively promote this form of co-creation. When taken in the context of Ostrom (1996) however it lacks certain elements: Ostrom sees co-creation as a way to close the gap between government and citizens. The Province of Drenthe and WMD actively discourage the closing of this gap by referring all citizens towards the project and maintaining a distant position within the project in relation to the farmers.

Framing water quality and quantity

To guide co-creation, it is necessary to know the involved stakeholders, relationships and interest. Co-creation is based on a mutual interest in a better future: stakeholders have to agree on the problem or even to agree there is a problem in the first place. During the interviews all participants have been asked to describe the problems they see in ground water quality and quantity in the area and the level of importance or urgency with these problems.

Water quality and quantity have been a largely non-visible aspect for farmers in the area. One farmer (F1C) indicated having previous experience with drought caused by water extraction. Water quality has been even less visible in the area, higher nitrate levels lead to higher crop yields and therefore are a positive indication for farmers. Nitrate reactions with heavy metals in the soil and the purification processes required to extract these pollutants from the drinking water also require specialist and in-depth knowledge not often found with farmers. Differences in the way stakeholders perceive water quality and quantity and frame problems therefore is expected.

A table has been generated from the interviews to indicate the responsibilities of the stakeholders, and their framing of water quality and quantity (table 4).

Table 4 Framing and responsibilities of stakeholders

	Responsibility	Framing
Province	• Protection of groundwater • Creating policy • Policy implementation • Land-use planning • Monitoring • Represent interests of inhabitants	• Many factors influence water quality and quantity • Nitrate is an important pollutant • Agriculture is the main source of nitrate • Physical conditions are unfavourable in Valtherbos-Noordbargeres • Current water quality is unacceptable
WMD	• Purification of drinking water • Supply of drinking water	• Nitrate is the main threat for clean ground water in Valtherbos-Noordbargeres • Current nitrate levels from agriculture conflicts with drinking water production
DLV	• Consulting farmers on achieving 50mg/L nitrate in groundwater • Business plan	• No own standpoint on water quality or quantity
Farmers	• Profitability and continuation of farms • Conform to rules and regulation	• Changing biodiversity is not equal to a problem • WMD and government should compensate farmers for sustainable agricultural practices • Better purification is a solution

The difference of framing between the Province of Drenthe and WMD on one side, and the other side the farming community is clear. Farmers indicate little to no problems regarding water quality regarding nitrates (F1C, F3D).

'You say nitrate problem, I don't know if it is a problem.' (F1C)

All farmers indicate pesticides as a pollutant and a more important factor for the area (F1-4). A large of concern for the farmers (F1,3,4) is the pesticides that are allowed in the water protection area. Pesticides need a special permit to be used in this area which makes introducing new (and cleaner) pesticides difficult and expensive for producers. This results in lack of alternatives as only older, more polluting pesticides are allowed, whilst new and better pesticides remain illegal.
Framing of farmers is defined by their personal experiences and therefore is closely related to their own farms. Drought was only mentioned by the crop cultivating farmer in relation to drought damages caused by drinking water extraction. Livestock farmers did not mention any quantity related problems. The biological farmer also related different to nitrate and pesticides as he himself is not allowed to use pesticides or synthetic fertilizer.

In conclusion farmers indicate the water quality and quantity in the area as adequate or even good. Which is in stark contrast to the Province of Drenthe and the WMD which indicate the water quality is not sufficient, and expect that even with the current project the quality norms will not be achieved in Valtherbos-Noordbargeres. Co-creation according to Albrechts (2003) can be used to align priorities and interests, differences in initial framing of problems can be disruptive for co-creation (Suskind, et al. 1999) and requires flexibility and willingness to adapt on both sides as stated by Bekkers, et al. (2014).

The Province of Drenthe indicates several external factors for water quantity and quality problems such as recent dry and hot summers and the unfavourable conditions of the soil. These external factors according to the Province of Drenthe increase the problems with the manure and fertilizer depositions of farmers.

An important difference between the WMD and the Farming community is the responsibility for the purification of the water. WMD expects the ground water quality to be stable or increase in accordance with EU regulation on groundwater quality. This is EU policy to safeguard water sources for drinking water in the future without having to increase purification efforts. Farmers (F1C, F3D) however question the necessity to decrease the purification effort, as water is still very cheaply available and no health effects have been perceived in the past decades. Instead the decreasing norms are seen as a way to keep people and companies relevant and in business by creating extra work.

'I'm not totally objective in this case, but as if the government is… they are dependent on advice from the RIVM and other institutes, and whether they are totally objective, I doubt it. But it's the best we have and they might not have another choice.' (F3D)

DLV has been hired as a consultant and has no direct stake in the area of Valtherbos-Noordbargeres. Instead they have been hired by the Province of Drenthe and WMD to guide farmers via study groups. They advise the farmers on sustainable agricultural practices and create awareness. Company visits are used to determine the current level of 'sustainability' of farmers and used to generate individual proposals for improvements. The current focus is on nitrate because of the 6th NAP, however other subjects such as pesticides are also part of their expertise. The long term of the study groups allows them to create bonds with individual farmers.

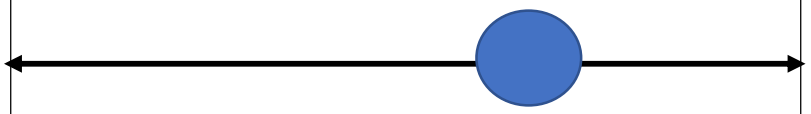
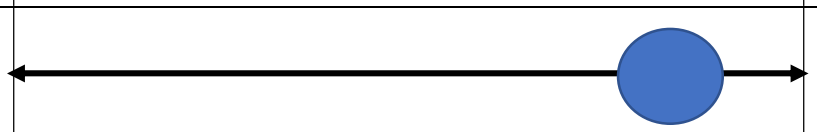
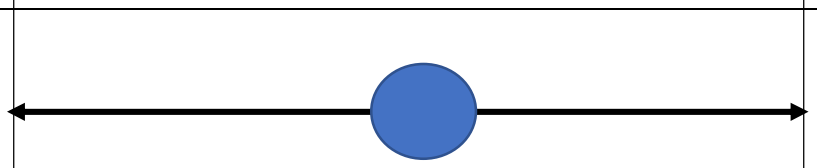
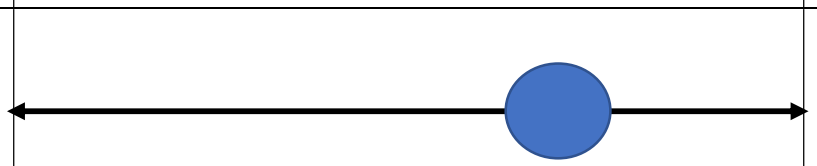
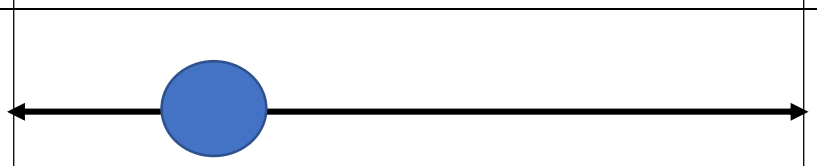
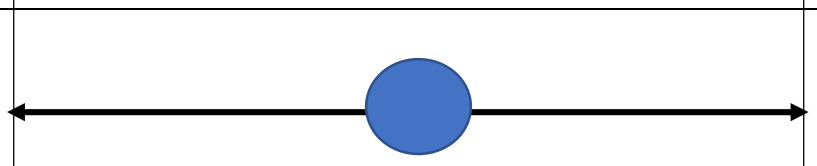
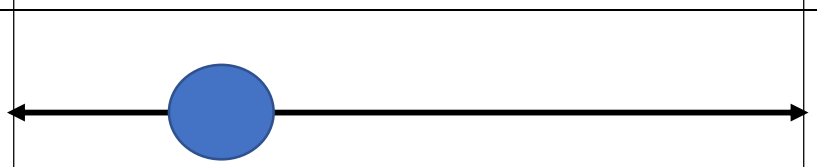
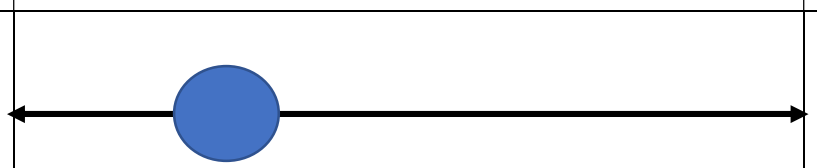
'Our common goal is stimulation of sustainable measures to ensure the nitrate norms.' (DLV)

4.2 Influences on willingness and abilities of farmers

(Question 7) What are the willingness and abilities of farmers for taking the lead in sustainable agricultural practices?

The conceptual model from chapter 2 shows how the willingness and abilities of the agricultural sector are influenced by several factors. These factors are: knowledge of water quality and quantity, previous experiences, influence on project, participation in project, framing of problems, resources for implementing measures, power balance in project and current legislation. Table 5 gives an overview of the perceived levels by the interviewed farmers.

Table 5 factors influencing willingness and abilities of farmers

Factor		Perception	
1. Knowledge of water quality and quantity	Low		High
2. Previous experience	Low		High
3. Influence on project	Low		High
4. Participation in project	Low		High
5. Framing of problems	No problem		Large problem
6. Resources for implementing measures	Low		High
7. Power balance in project	unbalanced		Balanced
8. Current legislation pressure	restrictive		open

The table is based on the analysis of multiple interviews with the farmers and is a generalisation of the individual perceptions. Differences in opinions between farmers have been acknowledged and will be discussed when appropriate.

The first factor is knowledge, farmers indicate a moderate to high knowledge on water quality and quantity. Knowledge on water quality and quantity is gathered mainly via the consultancies, the Province of Drenthe and WMD as they provide information with regards to the project. Several agricultural trade magazines (e.g. "Boerderij") infrequently publish about water quality and quantity, as do agricultural unions such as LTO. Colleagues provide a source of information especially in the study groups or during field work. All farmers participating have been active in the agricultural sector for at least several years, if not decades and have built up a large knowledge based on personal experience.

Not all farmers are familiar with the area dossier of Valtherbos-Noordbargeres made by the Province of Drenthe in compliance with the Water Framework Directive. Whilst this document is important as it describes the necessities and current situation of the area. This can be seen in line with the comment of one of the farmers (F3D) on 'official language', which can be hard to understand properly and easily. Trouble in understanding all information can lead to misunderstandings and disruptions. All stakeholders are proliferated in the Dutch language, however this is not the case for 'official language' or work jargon. According to Ramaswamy (2009) and Mauser et al (2013) differences and moreover specialisation in language can result in incompatibility to act on a larger (interdisciplinary or multilevel) scale.

An important part of the project is the 'kringloopwijzer' (environmental cycle guide) which indicates the ecological impact of the farm. These are made every year by an expert from the consultancy firm and are very detailed and informative. However, they are only useful when they are understood (F3D).

'The environmental cycle guide, which is part of the project, is very complex: it has hundreds of numbers I don't comprehend. Those numbers have a reason, but if I want to influence them, I need to know what they mean. So, you go to assumptions and less influence and that frustrates me sometimes.' (F3D)

The second factor is previous experience. All farmers have taken sustainable agricultural practices in the past: one farmer has even changed his farm into a biological farm. Yet these choices have not all been made from a sustainable goal. Economical gains have been the main driver in changing towards sustainable agricultural practices. Better milk prices (F2DB), lower costs for fertilizers or receiving compensations for withholding pesticides (F1-4) have been leading as well as the forced implementations of regulations. Previous sustainable practices have not led to any negative experiences; however, they have not led to systematic change towards sustainable practices from an environmental point. All farmers indicate a willingness to take more sustainable practices, yet only when these do not negatively influence the profitability of the farm. Burton & Paragahawewa (2011) describe a European trend of current Agri-environmental schemes (sustainable agricultural practices) not leading to a long-term attitude change.

The third factor is the influence on the project perceived by the farmers. Two conclusions can be made based on the response of the interviews. Firstly, farmers do not expect being able to change the policies of the Province of Drenthe (F1-4) (e.g. change norms and regulation). At best they hope that achieving the current targets would prevent stricter rules and regulation.

'Not waiting for regulations but take actions beforehand, rules will follow but maybe we can influence the rules, make them less harsh.' (F1C)

Secondly, they perceive a high influence on the implementation. The implementation on each farm is an individual process where the farmers retain full control over any and all new sustainable measures. The project is only advisory based.

'I ultimately decide what happens at my farm, I have the largest influence on that […]; whether it is wise is a different matter.' (F3D)

This perceived divide between influences is in line with the actor map conclusion of an agroecological co-creation between the advisories and the farming community, and the lacking co-creation between the Province of Drenthe & WMD with the farming community. The Province of Drenthe has a thinktank with farmers and is willing to engage in discussions on meetings or individual sessions, there is however no structured method of engaging with (all) farmers and incorporating it into policies (prov).

The fourth factor is participation. All farmers have been participating for several years or even decades. Attendance of the study group sessions is seen as important, both their own participation as the participation of others. Participation in study groups enables farmers to gain new knowledge to improve their farms (F1-4). Attendance of field work sessions therefor depends on the potential for gaining new and useful information, and sessions not perceived as useful will be skipped more easily (F2DB). A second factor for the perceived importance of attendance is the required combined effort to achieve the norms. All farmers perceive a select group of farmers which do not attend the meetings and sometimes low attendance at study groups or field work. Low attendance decreases motivation of participants. In relation to the influence of farmers on new policies a low attendance can decrease the democratic justification (Mannberg & Wihlborg, 2008). In the agroecological co-creation setting, little democratic justification is required as it does not produce new rules and regulation. In the larger scope of new policies, which would also be influenced by the outcomes of this project, democratic justification can become more important. The agricultural sector is the largest user of the land in the area and highly dependent on the outcome of new rules and regulation.

'It disappoints me how low the attendance at the meetings is, farmers make choices not to attend, which is difficult because you need to plan, prepare.' (F4D)

As indicated by the Province of Drenthe, only 80 out of 200 farmers in the ground water protection areas in the Province of Drenthe had the opportunity to participate in the project. This is based on the size of farms (minimum of 5 acres) and budgetary restrictions in the budget of the Province of Drenthe and WMD. The other 120 farmers did not meet the requirements, however are highly influenced by the results of this project as new regulation would impact them as well. This divide decreases their ability to influence policy, and relates to the power balance of factor 7.

Several farmers indicate a perceived diminishing return of investment from the project (F2DB, F3D). As a biological farmer the project offers fewer interesting prospects, many subjects of field work become irrelevant as it is not allowed to use pesticides or artificial fertilizers for example. Larger meetings with all stakeholders (Province of Drenthe, WMD, Royal haskoning etc.) appeal less to farmers as it offers little rewards (knowledge, influence) whilst consuming time or even money by attending. The 'official' language at these meetings also decreases the understanding and thereby motivation to participate (F3D).

The fifth factor is framing of the problem. Framing of ground water problems in a regional setting has already been discussed in chapter 4.1, this section relates towards the perceived individual influence on ground water quality and quantity. All farmers indicate a perceived positive effect of their farms on the ground water quality and quantity (F1-4). Control over their own lands leads to a perceived control over the groundwater quality and quality levels. Not applying artificial fertilizers and pesticides (F2DB), or staying within the set regulations of this moment (F3D) is perceived as a positive influence on the water quality and quantity. Current measures to increase efficiency also decrease nitrate leaching. The allowed levels of manure depositions are lower than preferred by farmers (F1C). Farmers are aware of the more difficult soil type in the area which retains nitrate poorly, however make no direct link towards lowering manure depositions. Farmers cannot control sources outside of their lands, this leads to a lower perceived influence. Finally a disbalance between perceived responsibility and having to solve all problems in the area is present with farmers (F1C) as the perceive their influence low, yet perceive a high pressure on solving the problem.

'We have to apply less and less manure, it is very important for us, but what is our influence, what comes from the forests' (F1C)

The sixth factor is resources for implementing sustainable agricultural measures. A perceived lack of resources can restrict the motivation to take new sustainable agricultural practices. Time, money, knowledge and supporting contacts are such resources, it is likely more resources would be applicable which would become apparent whilst implementing new sustainable measures. Time, money, knowledge and supporting contacts however are more easily estimated by farmers. Time is a scarce commodity and an hour spend extra on manure depositions cannot be spend on other aspects of the farm. As Rodriguez, et al. (2009) states, extra time requirements can lead to higher labour costs if personal needs to be hired. Age can also influence the amount of time available for sustainable agricultural practices, as new processes require effort and time to implement correctly (F3D).

'I'm not as young as I was, still full of ambition, but not young and ambitious.'(F3D)

None of the farmers indicate a sufficient financial position to take sustainable agricultural measures. High cost of machinery for precision farming, decreased milk prices, reluctant banks, uncertainty of profitability and labour cost (F1-4) were all mentioned by farmers as strong barriers.

'Banks are not as generous anymore, this is a barrier when doing things that don't generate a profit tomorrow but you are convinced of for the future' (F4D)

Important for the financial resource is the initial investment, and the return of the investment. High milk prices and crop yields allows farmers to invest more into sustainable measures. These measures however need to return the investment to the farmers within a certain timeframe to an attractive alternative to continuation of current methods. This return on investment also generates funds for future sustainable agricultural practices. Extra-legal sustainable agricultural measures required in the water protection areas are also unfair according to the farmers as farmers outside of the water protection area are not required to invest in them. Contact with WMD on compensation for these measures has been troublesome, tiresome and negatively impact the motivation of farmers (F1-4).

'Farmers are willing enough, however with WMD it becomes difficult, they always see obstacles and it is difficult to cooperate whilst they have the greatest interest.' (F2DB)

"They give some compensation for extra-legal, applied for it, send from the pillar to the post. They only take take take, but when it comes to giving……. That is not motivating.' (F4D)

The seventh factor is power balance in the project. Power imbalance is a large barrier for co-creation (Flyvberg, 1998). In the situation of Valtherbos-Noordbargeres it is clearly visible how the power balance influences the willingness and abilities of the farmers. Reluctance to share information is a barrier described by Flyvberg when a power imbalance becomes too large and is present with the farmers (F1C, F3D).

'*I had difficulty supplying data. Will it be used fairly, that is difficult to say.' (F1C)*

Arnstein's ladder (1969) can be used to indicate the power balance between stakeholders, in this case the Province as the governing stakeholder against the farming community. Farmers perceive a different balance than the Province perceives. The difference relates to the two different scopes of co-creation: the agroecological co-creation between the consultancies and the farmers which gives farmers more support and actual power over implementations, whereas the larger scope of regional long-term decision making has little opportunity for farmers to apply power. Farmers indicate the power balance somewhere in the range of 'consultation and informing' as they see little to none possibilities to influence the larger scope (F1-4). Whereas the Province indicates the current situation as placation.

The Province sees the larger regional scope as a 'simple' problem (De Roo, 2013) with structured norms and regulations where little decision making is required (prov), this has already been done on a EU and national level. The Province is also forced into a more technical rational approach via short time frames and national policy. This has been labelled 'dwingende reden voor groot openbaar belang' which translates to 'compelling reason of large public importance' and decreases the flexibility of the Province of Drenthe. Because of this perceived simplicity placation has been deemed an appropriate level of co-operation. This is in contrast with the farmers as they see the problem in a larger context of their continuation, liveability and historical context which creates a complex system of interdependency more suited for a collaboration between the governing body (the Province of Drenthe) and the farming community (F1-4). WMD is perceived by the farmers as a large influencer on the rules and regulation for the area which is not open for constructive collaboration (F1-4).

'The satisfaction of farmers could improve if they would listen more to us, we have been to the WMD a few times, but they would not listen to us, it's a cumbersome entity and the director decides everything.' (F2DB)

The eighth factor is current legislation pressure. A high pressure is perceived by the conventional farmers as well as conflicting legislation. Not all manure can be used and farmers are required to dispose properly and expensively, whilst artificial fertilizers can be bought and applied on the same land (F3D). As previously mentioned, the allowed pesticides in the area are not the newest and least polluting because of strict and expensive introduction procedures (F1-4). The biological farmer indicate only a moderate pressure from regulation as many rules and regulation don't apply or are more lenient than the criteria for being a biological farmer.

A factor mentioned by the farmers, which was found inductive during the interviews, is the perceived level of trust (F3D, F4D). Farmers indicate a perceived lack of trust from the government towards the agricultural sector. This is perceived in ever increasing control and creating rules and regulation for everything.

'If everybody was honest and acted in good faith, we would be able to do much more.' (F4D)

Trust is both perceived as farmers not being trusted by the government (Province, national) and the farmer not being able to trust the government. As mentioned earlier as part of the power balance,

trust in the government to use data and other input from the farmers, or even objectivity and honesty from the government is sometimes lacking. Mistrust is a large barrier in co-creation as co-creation is based on openness, equality and a fairness (Gliessman, 2018; Milgroom, et al. 2016; Ramaswamy & Ozcan, 2018).

4.3 Barriers for co-creation

(question 7) What barriers for implementing sustainable agricultural practices are perceived by farmers?

Barriers can restrict the process of co-creation, negatively impact the willingness and abilities of participants, and delay or make impossible the implementation of sustainable agricultural practices. A myriad of barriers have been mentioned in the interviews by all stakeholders. Perceiving a barrier limits a person, even when the barrier of perception does not match the actual proportion or existence of the barrier (hoogendoorn, et al. 2019). Barriers can be multifaceted and difficult to properly place into one category, for clarity barriers will only be placed into one category. Barriers for implementation of sustainable practices can be seen as separate from barriers for the process of co-creation, however barriers for implementing sustainable practices influences the willingness and capacities of farmers and thereby influence the process of co-creation, as co-creation in the agroecological form is highly dependent on the abilities of farmers and place based. The perceived barriers for farmers found during the interviews are divided into 4 categories. New barriers might emerge when the process of co-creation develops in the future, the current number of barriers is not finite.

The first category involves personal barriers which are dependent on the persons themselves.

1	Availability of time	Farmers
2	Availability of knowledge	Farmers
3	Lack of personal interest	Farmers
4	Framing of problems	Farmers

Table 6 Personal barriers

Personal barriers influence the willingness of farmers to a large degree. Farmers take sustainable agricultural measures; however, these have not been taken from an ecological perspective but from an economical perspective or legal pressure. For example, the change from conventional farm towards a biological farm was not made for ecological purposes, but was mainly based on the higher milk price and thereby maintaining a more profitable farm when regulation required a downsizing of dairy cows (F2DB). There was no long term wish present to increase sustainable agricultural practices at the farmers which is in line with the claims of Burton & Paragahawewa (2011) on lacking long term effects. Previous sustainable agricultural measures are taken into the context of financial gains, and new measures will primarily be based on profitability first. These barriers do not create an unwillingness towards sustainable agricultural practices with the farmers, however is prohibits the initiating of new measures for a better ecology by the farmers themselves.

'[…] that's when we took the step to biological, it's not like you can have more dairy cows, but you get a different milk price, a different way of farming. I think it's slowly moving in that direction.' (F2DB)

The second category is interpersonal barriers. Interpersonal barriers related to the connections and relationships between stakeholders (see table 7).

1	A lack of trust between farmers and the government	Farmers
2	Feeling mistrusted by the government	Farmers
3	Mistrust of information	Farmers
4	Perceived unfair distribution of responsibility	Farmers
5	Negative previous contact between farmers and WMD	Farmers
6	Negative view on the consortium's 'overhead'	Farmers

Table 7 Interpersonal barriers

Interpersonal barriers are based on trust issues, unfairness and negative previous experiences. Trust issues originate mainly out of negative experiences and a lack of understanding between farmers, and the Province of Drenthe and WMD. Farmers have no complete understanding of ground water quality and quantity systems, changes in norms, regulation etc. are not in line with the perceived experiences of farmers whom notice no negative effects of excess nitrates. It even juxtaposes their position of preferring more nitrate for higher crop yields and better grassland. A system of questioning the government has also been present in recent years (prov), for example 'the farmers defence force' although none of the farmers indicated this as a source of information it still can create doubt on the honesty and correctness of governmental agencies. Lack of understanding also influences the perceived negative view on the consortium's overhead. The Province of Drenthe hired the consortium which include several companies whom have no direct involvement with the farmers. Farmers connections are limited to the consultancy firms as demonstrated in the actor map. More companies have been added in recent years whilst study group sessions have decreased, this creates the perception of wasting money on bureaucracy.

'I think a lot of money goes in the overhead of the project; I would rather see the money in the consultancy.' (F4D)

Unfair distribution of responsibility strongly relates to the framing of problems, clean drinking water is an important commodity. Clean drinking water is used by all citizens in the area, farmers however are held more responsible for influencing the ground water supply with strict rules and regulation. Regular citizens do not meet these strict rules and regulations, nor do they pay for the implementation of more sustainable agricultural practices. For example, a small increase in the water price to support sustainable agricultural practices would share the perceived responsibility with the rest of the population which also profits from the agricultural products, and better water quality and quantity of the farmers (F1-4).

'The entire population profits from us doing our best, however we have to pay for it.' (F1C)

The third category is external barriers. External barriers are based on the institutes and the place in which the sustainable practices have to be taken (see table 8).

1	Conflicting and strict rules and regulation	Farmers
2	Difficult soil types	Farmers, prov, WMD
3	Difficult crop types (low nitrate retention)	Farmers, prov, WMD
4	Political pressure	prov

Table 8 Environmental barriers

The place in which co-creation exist is formed out of institutions and the physical area, barriers within this place are seen as external barriers (they are outside of the farmers direct influence). Soil types and nitrate retention of crops are not easily influenced by farmers. Farmers don't directly see them as

barriers for implementing sustainable agricultural practices (F1-4), however the Province of Drenthe and WMD see them as important barriers for reaching the desired level of 50mg/L nitrate in the ground water. Political pressure is also perceived as a barrier for co-creation by the Province of Drenthe, the allotted times and political pressure to achieve the targets result in a more technical rational approach (prov).

The fourth category is financial barriers. Financial barriers relate to all monetary constraints in implementing and continuation of sustainable agricultural practices

1	High investment cost	Farmers
2	Unpredictable or little return on investment	Farmers
3	Market restrictions	Farmers
4	State aid regulation	prov
5	Difficulty acquiring loans	Farmers

Table 9 Financial barriers

The financial situation of farmers is highly dependent on crop yields and milk prices. Sustainable agricultural practices can increase or decrease the cost of production for a certain number of crops or milk. The unpredictability of untested and unfamiliar new methods creates a barrier for experimentation. A new tractor and equipment can cost hundreds of thousands of euros as investment, banks have become more reluctant with loans for untested methods which creates another barrier for unproven methods. The Province cannot provide financial incentive to farmers as it fears conflicting the state aid regulation, this would also impact the budget for the Province negatively. The market creates barriers for farmers: a large portion of consumers always buys the cheapest available options. Biological milk for example is more expensive: producing biological milk is more costly than non-biological milk. Unless more consumers start buying biological milk the change towards biological and more sustainable farming will not continue. These financial barriers negatively impact both the abilities as the willingness to invest in sustainable agricultural measures.

'If the consumer gets the cheapest product in the store, yet screams we should we have to do this and that, it's not going to work.' (F2DB)

5 Conclusions and discussion

In this chapter the research question is answered. Sub-questions have been used in this research to form a scientific basis to the answer of the main question. In section 5.1 the sub questions will be answered, which are based on the results of chapter 2 and 4. The primary question '*How can co-creation between farmers and the water sector support willingness and abilities for farmers to take the lead in sustainable agricultural practices improving water quality and quantity in South east Drenthe?*' will be answered at the end of section 5.1. section 5.2 will discuss the strengths and weaknesses of this research.

5.1 Conclusion

This study researched the possible benefits of co-creation in supporting farmers in taking a lead in sustainable agricultural practices. In order to understand the situation, the specific case of Valtherbos-Noordbargeres was analysed. Generic questions for understanding the principles of co-creation, qualitative and quantitative problems and sustainable agricultural practices have been answered in chapter 2. Specific questions on relationships, willingness and abilities, and barriers have been answered in chapter 4.

The first generic sub question was: which water problems (quantitative and qualitative) are created by farmers in south east Drenthe, what are their spatial dimensions? According to current literature on agricultural impacts manure and pesticides provide the largest water qualitative problems. This is corroborated by the Province of Drenthe and WMD. The main focal point of the Province and WMD are the nitrate problems, and has resulted in a project for better drinking water. The focus has been given by the 6th NAP which in turn is a result of EU policy on nitrate levels and drinking water supplies. The spatial dimension of this focus is the water protection area of Valtherbos-Noordbargeres in which a drinking water well is run by WMD. Quantitative water problems are not part of the project for better ground water, however dry and hot summers of recent years also affect the water quality as more nitrate leaches into the ground water if crops can't retain them properly in dry periods.

The second generic sub question is: how is the governance on water structured? Water governance is very structured in the Netherlands (see chapter 2.2) and highly influenced by EU policy. The European Water Framework Directive (WFD) and the nitrate directive have been put into national legislation, the 'kader richtlijn water' and the manure and fertilizer act. The Province is held to the WFD and drinking water act and has the obligation to ensure clean ground water, and to decrease the required cleaning for drinking water production. WMD has no obligation to ensure clean ground water by law. The Province creates regional plans to ensure clean ground water which affects the farmers in the area of Valtherbos-Noordbargeres. The farmers are also directly influenced by the national government with the manure and fertilizers act as this surpasses the provincial level.

The third generic sub question is: which stakeholders are part of the water sector in SE Drenthe? The water sector in Valtherbos-Noordbargeres exists of the Province of Drenthe as responsible for ground water quality and regional planning and the WMD as producer of clean drinking water. The waterboard 'Vechtstromen' is a part of the water sector in the area, who however is not involved in the project for better ground water as it only focusses on surface water. The municipality of Emmen also has not been involved in the project as a partner. Other stakeholders such as Vitens (drinking water company) are active in the Province of Drenthe, however they are not active in the area of Valtherbos-Noordbarges.

The fourth generic sub question is: what are 'sustainable agricultural practices', and how can these practices benefit groundwater quality? As described in the literature (see chapter 2.4), sustainable practices have their basis in three important aspects: environmental improvement, economic

feasibility and social sustainability. This research defines sustainable agricultural practices as: 'any practice that improves the quality or quantity of ground water without a (significant) degradation or improvement towards the economic and social stability of the system'. This definition diverts from most definitions in the literature as these focus on food shortages in less advanced agricultural settings. Sustainable agricultural practices influence the ground water by reducing leaching of nitrates, reducing pesticides, improving soil quality and reducing the water requirements and extraction.

The fifth generic sub question is: what is co-creation, and how can it influence willingness and abilities of farmers to adapt? Co-creation is a form of collaborative planning and is described in the literature (see section 2.3) in a more general situation as: *"a process through which inputs from individuals who are not 'in' the same organization are transformed into goods and services" (Ostrom, 1996, P1073).* Co-creation is also described in an agroecological setting were academic and agriculture are combined to gather knowledge and fill missing gaps (Gliessman, 2018; Milgroom, et al. 2016; Ramaswamy & Ozcan, 2018). Co-creation can influence the willingness and abilities of farmers by increasing the willingness as farmers become part of the planning process, by aligning priorities and interests (Albrechts, 2003), and increasing the abilities by generation social capital, resource sharing and increased knowledge.

The first empirical question is: what are the willingness and abilities of farmers for taking the lead in sustainable agricultural practices? None of the participating farmers indicated a willingness in taking the lead in sustainable agricultural practices. Farmers indicate little to none perceived problems with water quality and quantity in relation to nitrate and perceive the current methods of farming as adequate or good (see section 4.1). The ability of farmers to implement sustainable agricultural practices are perceived as moderate, resources required such as time, money, knowledge and helpful contacts can be utilised. Money being a more problematic resource as investors need a 'guaranteed' return on investments, which can hamper more experimental practices.

The second empirical sub question is: what barriers for implementing sustainable agricultural practices are perceived by farmers? Four types of perceived barriers have been identified during the interviews: personal, interpersonal, external and financial (see section 4.3). The current situation has several barriers which impedes any co-creative process whereby the farming community could influence the regional policies. The Province of Drenthe actively pursues a technical rational approach for this planning. In the agroecological setting of consultancies and the farmers less irrevocable barriers for implementing sustainable agricultural practices are present, these mainly focus on finance, trust and relationships.

The third empirical sub question is: what are the formal and informal relations between stakeholders? Four main stakeholders have been identified which have close relationships: the Province of Drenthe, WMD, the consortium and the farmers. An actor map (see section 4.1) has been made to visualise the relationships. Farmers have a strong formal and informal relationship with the advisers from the consortium, however they lack any relationship with the Province of Drenthe and WMD. The Province of Drenthe and WMD have a very strong formal relationship as they created a joint work group which in turn has a strong formal relationship with the consortium as client and contractor. These relationships directly influence the potential for co-creation, strong relationships between the advisers and farmers have enabled an agroecological co-creation to flourish, a weak or non-existent relationship with the Province and the farmers does not enable a co-creation on the planning for the future of the region on a larger (governmental) scale.

The primary research question was as follows: '*How can co-creation between farmers and the water sector support willingness and abilities for farmers to take the lead in sustainable agricultural practices improving water quality and quantity in South east Drenthe?'* Based on the interviews with all stakeholders two main conclusions can be drawn. Firstly, the agroecological co-creation between the advisors of the consortium and the farmers has a positive effect on the willingness and abilities of farmers for taking sustainable agricultural measures. However, it is clear farmers don't have the same perception on water quality and quantity problems as the Province of Drenthe and WMD have. This fundamental difference in perception is the main barrier for farmers in taking a lead, co-creation should focus on aligning interests, sharing knowledge, trust and honesty. The current agroecological co-creation is strong in functional co-creation (knowledge, research) however it lacks in the sociological aspect of creating a long-term Agri-environmental paradigm.

Secondly, current setup of the planning procedure of the Province of Drenthe leaves no room for co-creation in long term planning for the area. This creates a distance between the Province of Drenthe and the farming community which could be utilised to align priorities and find mutual interest. Co-creation on this larger scale could prove beneficial if utilised to increase the change to an Agri-environmental mindset in farmers. A change from the technical rational approach currently employed by the Province of Drenthe however could prove difficult due to national legislation and set timeframes.

5.2 Discussion

A fundamental flaw in the conceptual model (see chapter 2.5) has to be acknowledged in relation to the outcomes of the research question. The conceptual model already proposed a certain degree of mutual interest, and common ground to start from. However, this is not the case as can been seen in the interviews. This is a disruptive force for the process of co-creation. Another difference from the conceptual model is the setting of the current co-creation which focusses on the agroecological cooperation between the advisors and the farmers, instead of the expected water sector (i.e. the Province of Drenthe and WMD), whilst any co-creation between the Province of Drenthe and WMD is actively countered.

One contradiction with co-creation in the literature is based on the difference in viewpoint on water quality and quantity problems. Although the starting points between farmers and the water sector are opposite (no problem vs strong problem), an active and productive agroecological co-creation ensued in contrast to expectations based on Susskind (1999). Even more intriguing is the continuation of the viewpoint of the farmers and the water sector during the process, as co-creation is supposed to bring together and learn from each other (Gliessman, 2018; Milgroom, et al. 2016; Ramaswamy & Ozcan, 2018). It might even be stated that the current setup of agroecological co-creation can be placed in a more technical rational approach as a tool for governing. Which is an interesting viewpoint for planning practice and planning theory.

6 Reflection

The research setup of this thesis was based on an in-depth case study of a select group of farmers in the area of Valtherbos-Noordbargeres. The area was selected on the premise of an interesting project found by the Province of Drenthe and WMD relating to cleaner ground water, and a difficult physical situation with dry sand grounds. It was expected to be possible to participate during study groups and field work sessions to gain a hands-on first-person impression of the project, relationships and willingness and abilities of farmers. However, the period in which the data gathering and visits of the study group where planned coincided with the introduction of the corona virus in the Netherlands.

The university did not allow for personal meetings or interviews. The study groups, meetings and field work sessions all have been cancelled for the entirety of this thesis and have no clear date of resuming.

The cancelation of the project for this period, and recent changes in personal at WMD made data gathering more difficult, interviews where held via telephone instead of in person, which resulted in a lower sound quality which coupled with a 'Drents' accent can become troublesome to understand at moments. Non-verbal communication is missing from these interviews. Explaining complex factors to interviewees without non-verbal communication (e.g. a simple sketch) is more difficult.

Nonetheless an interesting conclusion for the primary question was able to be found. The results of this thesis have been highly dependent on a small portion of the participants. A different set of interviewees would undoubtedly create different nuances if not a different outcome. This is a thing to be mindful of when using in depth case study approaches as a research method.

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