

LONG TERM CLIMATE ADAPTATION FOR AGRICULTURE ON DUTCH PEATLANDS

Bachelor Thesis



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Summary

Wetlands cover approximately 6% of the world's land surface, but contain 12% of the global carbon pool, thereby playing an important role in the global carbon cycle. Climate change affects Dutch peatlands and wetlands, as more energy is needed to keep groundwater levels suitable for agricultural needs. In the Netherlands large sections of agricultural lands are located in these peatlands. Different studies suggest that adaptations to climate change must be made in Dutch peatland areas, to sustain future farming in Dutch peatlands.

These adaptations lead to a field of tension between: legislators, water boards and farmers in Dutch peatlands. Different perspectives and goals set by these actors make it difficult for solutions to be realized that are backed by all actors. This thesis research elucidated on these discourses and gives recommendations for a climate-smart measure that is beneficial for all actors involved.

The objective of this thesis was to understand the different stakeholders' perspectives about climate-smart agriculture practices in Dutch peatland areas, that are applicable with current groundwater management practices.

For this study social constructivism was selected as metatheoretical framework since this framework was able to help explain the complexity of the discourses and the interactions between the actors in Dutch peatlands. Building on this constructivist approach a discourse analysis was used to understand the perspective frames of the stakeholders. University lecturer and social science and area studies scholar Florian Schneider (2013) developed a series of ten steps to help conduct a systematic and professional discourse analysis, these steps were used to guide this research. By conducting an explanatory case study research into the cases of "*Midden-Holland*" and "*Waterland*" was this research able to achieve its objective.

The works of S.S. Meijer et. Al. (2015) helped to design the conceptual model for this research. This conceptual model defined that first the characteristics of the: external environment, farmers and the climate-smart agricultural measure had to be analyzed. Followed by an interpretation of the discourses between the actors involved.

In understanding the perspectives this research concluded that the most tension is visible between farmers and legislators. Farmers are generally willing to adapt new measures as long as they are profitable for their business. Government grants for the realization of under water drainage systems can improve the profitability of this system and thereby making the measure financially more interesting for farmers. It is this underwater drainage systems that can improve the environmental situation by reducing greenhouse gas emissions as well as slowing the rate of subsidence in farmlands. Food security is then achieved since farmers have longer growing seasons and the effects of wet and dry situations are levelled by the drainage system.

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1. Introduction

1.1 Background information

Wetlands cover approximately 6% of the world's land surface (World Wildlife Fund, 2018). These wetlands are home to a broad spectrum of biodiversity. Large quantities of mammals, reptiles, amphibians, fish and invertebrate species are found in wetland habitats (Parish & Looi, 1999). Peatlands are an example of a wetland that is a common soil type in the Netherlands. In figure 1 a simplification of the Dutch soil types is shown. Clear to see is in this figure is that large areas of the Netherlands have peat as a soil type.

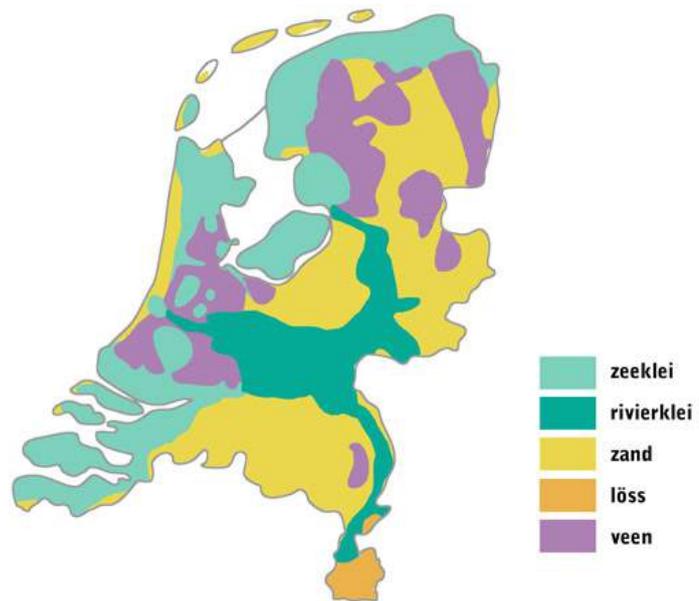


Figure 1: A simplification of the soil types in the Netherlands. Areas with the color purple show peatlands which are mainly located in the northeastern and western parts of the Netherlands (van de Wittenboer, 2018).

Wetlands contain about 12% of the global carbon pool, playing an important role in the global carbon cycle. In a world of global climate change, wetlands are considered one of the biggest unknowns of the near future regarding element dynamics and matter fluxes (Erwin, 2009; Mitsch, et al., 2013). Peatlands are soil types naturally rich of water and contain half-decomposed plant remains. The water table in Dutch peatlands is often lowered in order to sustain agricultural practices and for maintaining land for built-up areas. The lowering of the water table causes subsidence in peatlands as plant matter in turn oxidizes and shrinks. This subsidence causes the emission of greenhouse gasses, such as carbon dioxide or CO₂. Dutch peatlands emit a similar amount of CO₂ as that of an average coal-power plant (Ekker, 2017). Besides the release of CO₂, is land subsidence mainly affecting the foundations of buildings. In some areas the land is subsiding at an average rate of 1 centimeter per year (Korevaar & van der Werf, 2014; Hendriks K. , 2018). Current Dutch peatland management, in favor of agriculture, continues subsidence of land by a continues lowering the water table. Although some forms of agriculture and newer forms of management slow the rate in which the land is subsiding, do all measures eventually still cause for the lowering of land (Smolders, et al., 2013).

Climate change affects Dutch peatlands and wetlands, as more energy is needed to keep ground water levels suitable for agricultural needs. Over 2,3 million hectares in the Netherlands are used for agricultural purposes, although only about 2.2 of the Dutch gross domestic product is generated by agriculture. The Netherlands is an important player on a global scale in trading agricultural products (Landbouw in Nederland, 2018). Large parts of the Dutch agricultural lands are located in the peatlands of the Netherlands. Climate change is affecting the way the Dutch organize the agricultural land in peatlands. Climate change and anthropogenic activities will affect groundwater quantities and qualities in the near future. This is due to rising sea-levels which trigger intrusion of saline water into the groundwater of the subsiding peatland areas (Oude Essink, van Baaren, & de Louw, 2010). In order for Dutch peatlands to remain in function at sea level, more groundwater needs to be extracted and

discharged to open waters and eventually the sea. Thus, salinization of the land has an extra strengthened effect because of Dutch water management. Future climate change will further impact saline intrusion into groundwater sources (Wageningen UR Livestock Research, 2011; Oude Essink G. , 2001). Agriculture might not be possible in its current shape if salinization levels of the groundwater continue to rise.

In the Netherlands 6 out of 17 million citizens live on 'weak' soils such as the peatlands in the provinces of North- and South Holland. As mentioned earlier, keeping the land suitable for agricultural activities increases the pressure on these weak soils. The subsidence of peatlands causes economical damage as the structure of the ground is altered. It is estimated that per person the Dutch contribute up to €250 in taxes to sustain maintenance for public works (Boersma, 2015). Eventually a continuous subsidence of the land threatens Dutch water management as more effort is needed to maintain coastal defense, so flooding is prevented. Most of the agricultural land is for the grazing of livestock. The classical Dutch landscapes with dairy cattle and windmills are common viewpoints in the provinces of North- and South Holland, see figure 2. Cattle is an important economical factor in the peatlands of the Netherlands, famous Dutch cheeses are derived from these peatland areas. Meat and dairy exports were both in the top 3 of agricultural products in 2015 (Asscheman, 2017; Hoes, Beers, & van Mierlo, 2016). All in all, cattle farming is a significant economical player in the Dutch peatlands. Although, the composition of peatlands has a negative effect for arable farming, it is suitable for handling livestock. Thus, cattle farming is the most common agricultural practice in peatland areas. (van Trikt & Ahrens, 2018).



Figure 2: Image of a 'typical' Dutch peat landscape. Dairy cattle are grazing in front of a windmill (Bassa, 2016).

Different studies suggest that adaptations to climate change must be made in Dutch peatland areas, to sustain anthropogenic activities and maintain fresh-water drinking supplies and natural ecosystems in Dutch peatlands (Oude Essink, van Baaren, & de Louw, 2010). An increase of salinity levels in ground and surface water cause for a range of problems in peatland areas. More saline water will lead to a decrease in irrigation and drinking water resources. Water shortages, will lead to economic losses in agricultural and industrial businesses, as crops and grasslands can no longer be sustained. Increasing groundwater levels land subsidence will do the most damage to urban areas, as foundations and infrastructure in the soils are damaged. The effect of changing groundwater levels due to climate change and groundwater management for urban areas, include: rotting (wooden) poles, subsidence of buildings, and land subsidence of peat areas in rural areas (Buma & Bootsma, 2017). In contrast to rural areas damages in urban areas can be prevented by investing in better drainage systems (Oude Essink, van Baaren, & de Louw, 2010).

Therefore, adaptations must be made to sustain agriculture practices in the Netherlands as salinization levels of surface and groundwater are increasing. New technologies and research provide alternative agricultural practices for peatlands. However, farmers, legislators and Dutch water boards all have different views and opinions for the future of Dutch peatlands.

Researchers H. Oostindie, D. Roep and H. Renting (2006) concluded in their research into multifunctional agriculture, that opinions and arguments of politicians are characterized by mainly the competitiveness of farming. Also, pollution and land-use conflicts because of the high population density in the Netherlands are strong objects of opinion. Farmers however, are more concerned with their revenues and their business strategies. An important strategy could be to ensure the 2020 targets for a future-proof and responsible dairy sector by the Dutch Sustainable Dairy Chain (Hoes, Beers, & van Mierlo, 2016). These future-proof targets include: climate neutral development; improving animal welfare; maintain outdoor grazing and the environment. The initiatives by the Dutch Sustainable Dairy Chain are contributing towards more sustainable agriculture, the process is however still ongoing and actual results are therefore hard to measure (Hoes, Beers, & van Mierlo, 2016). On the other hand, investments in farming innovations are sometimes halted by banks, as banks are reluctant in financing innovative agricultural practices as these capital investments contain more risks compared to other investments (Bremmer, et al., 2016).

Several discourses can already be distinguished between major actors in this case study and research. The different perspectives and goals set by the actors make it difficult for solutions to be realized that are backed by all actors. This thesis research will try to elucidate on these discourses and tries to define climate-smart agricultural practices that are applicable for the research cases studies.

This thesis will focus mainly on the region ‘*Midden-Holland*’ in the province of South Holland. In initial research this area proved to be the most useful for this research as the area contains extensive areas of peatland and agriculture. In comparison the region of ‘*Waterland*’ in the province of North Holland will be used to elaborate upon differences and challenges. In figure 3 the locations of the regions within the Netherlands are shown.

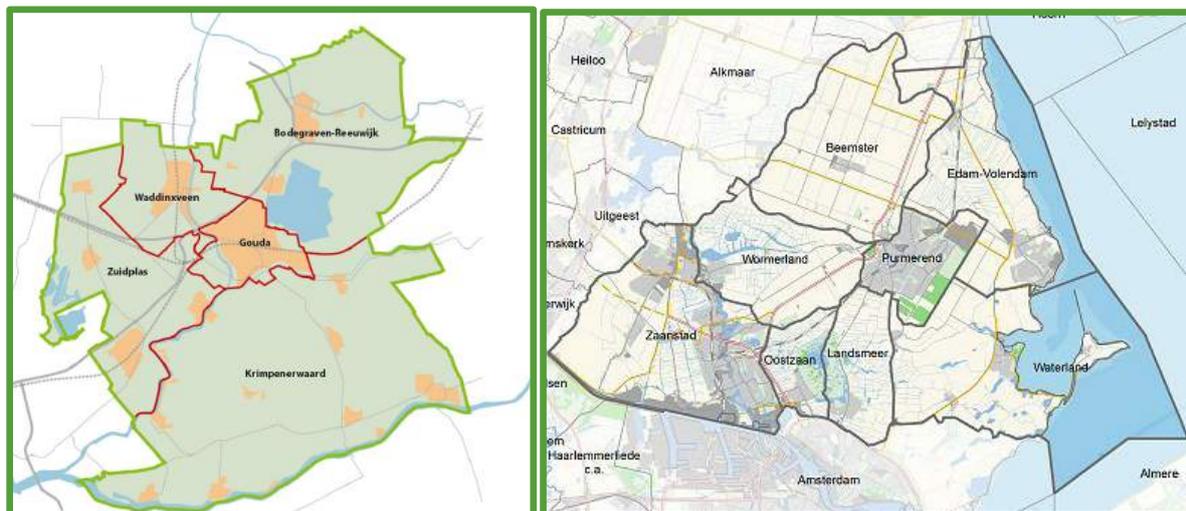


Figure 3: Map showing the research areas of this thesis research. On the left the region of *Midden-Holland* is displayed. As seen this region surrounds the city of Gouda. On the right the region of *Waterland* is displayed, this region is located in between and around the cities of Zaandam and Purmerend (Provincie North-Holland, 2018; Regio Midden-Holland, 2018).

1.2 Objective

This thesis aim is to understand the different stakeholders' perspectives about climate-smart agriculture practices in Dutch peatland areas, that are applicable with current groundwater management practices.

1.3 Scientific Relevance

As mentioned in the previous paragraph, is the Netherlands a small country located in a wetland with large areas of peatland. And because of climate change more energy is needed to keep land suitable for agriculture (Landbouw in Nederland, 2018). This research's aim is to understand the different stakeholders' perspectives about climate-smart agriculture practices in the Netherlands. Nonetheless, can the results be extrapolated for cases beyond the Netherlands, this will be discussed in the sub-paragraph external validity. The relevance of this thesis research can be split into two parts.

Firstly, climate change is changing global temperatures, precipitation levels, sea levels and other natural forces. The Netherlands is vulnerable for the effects of climate change, as large areas of the Netherlands are around or below sea level. As mentioned in the situation review, agriculture in peatlands is vulnerable for changes in groundwater salinity and water levels. In order for agriculture to be viable and profitable in the (near) future, adaptations must be made to sustain agricultural practices in Dutch peatlands (Buma & Bootsma, 2017; Oostindie, Roep, & Renting, 2006). Since the Netherlands needs to change their agricultural practices in the future, will this research provide an overview of the different perspectives and opportunities with current developments.

Secondly, little research is conducted into smart-climate agricultural practices for agriculture specifically in Dutch peatlands. The "*Peatland Innovation Center*" (in Dutch: Veenweiden innovatiecentrum) is an experimental program in which actors involved in agriculture in peatlands are experimenting and researching innovations. Near the small town of Zegveld in the Netherlands an experimental farm was set up to test the implementations of measures for the sustainable use of future agriculture (Veenweiden Innovatiecentrum, 2015; Erwin, 2009). It is only this physical experimental project that is supports in research for agriculture in Dutch peatlands. This thesis will therefore contribute to existing knowledge by providing a discourse analysis of the actors involved in smart-climate agriculture in peatlands. The conclusions of this research will help to provide a better understanding of the current developments in smart-climate agriculture in the Dutch peatlands of South Holland.

External validity

The external validity of a research shows the generalization of the results, derived from this thesis, that are applicable to similar cases elsewhere (Mitchell & Jolley, 2012). As mentioned this research solely looks at two cases, to elucidate on the current developments in smart-climate agriculture in the Netherlands. The results of this research are nonetheless generalizable for similar areas in the Netherlands or beyond.

Worldwide peatlands are beneficial for both the human and the non-human environment. Peatlands for example: reduce greenhouse gasses by absorbing CO₂ gasses, prevent flooding; create water security and houses large amounts of biodiversity (Tinhout & Wetlands International, 2018; Knight, 1997; Larsen & Harvey, 2010). The storage of mainly CO₂ is important for the worlds carbon cycle, as peatlands store significantly more amounts of CO₂ compared to other soil types. Peatlands are worldwide being converted in other soil

types to ‘benefit’ the needs of men (Schils, 2012). The peatlands in this researched case are part of the Rhine river delta which is heavily populated by humans. This research therefore contains elements that are applicable for similar heavily populated river delta’s worldwide (e.g. the Yangtze, Mekong, Nile, Mississippi and the Ganges river systems). As these systems all have different types of peat and wetlands that are (miss-) used by agricultural practices (Misachi, 2017; Britannica, Inc., 2018).

1.4 Case selection

Peatlands in the Netherlands all have different geological origins and formations. As seen in figure 4, most of the peatlands are generally located in the Western and in the Northern parts of the Netherlands (Berendsen, Landschappelijk Nederland, 2008a). The main criteria for the selection of a region/case in this case study is that location provides extensive areas of peatland and agriculture is commonly practiced within this region. Based on the schematic map by Berendsen (2008) as seen in figure 4, the peatlands in the provinces of: North Holland, South Holland and Friesland, are applicable for this research since these locations contain wetlands. By conducting initial research, the case of ‘Midden-Holland’ in the province of South Holland as exemplary model was selected as main research case.

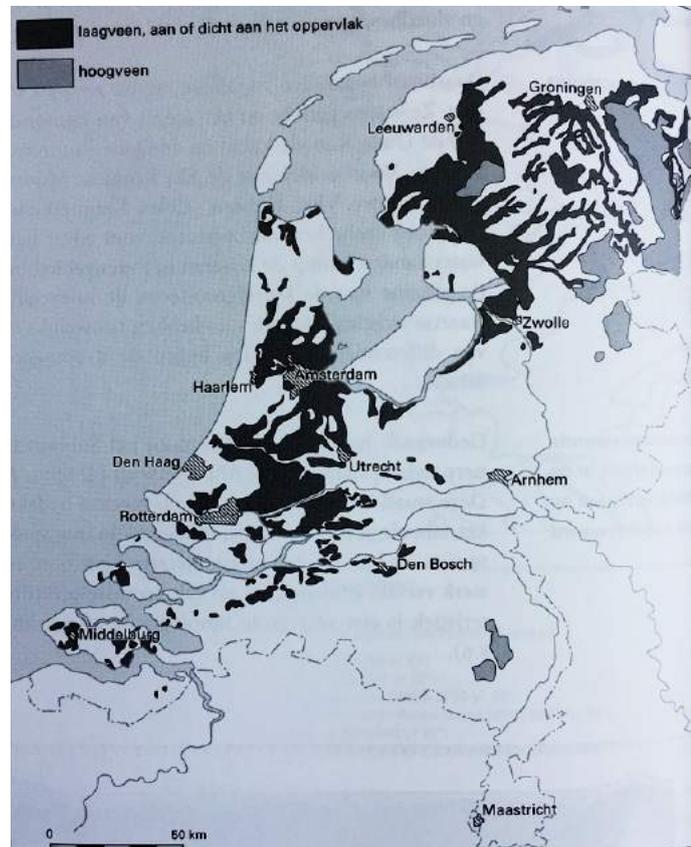


Figure 4: location of peatlands in the Netherlands showed in light grey raised bog and in black wetland or fens (Berendsen, 2008a).

Because this case houses the combination of peatlands, agriculture and history that are typically considered as a classical Dutch landscape. One main case is selected in this thesis, since research by Driessen, et al. (2015) defined that each peat meadow area requires a separate regional adaptation strategy. Since this separate strategy keys into its specific physical and socio-economic properties. As a comparison the case of the region of ‘Waterland’ in the province of North Holland was selected. Both cases were selected because they contain extensive areas of peatland are used for agriculture. In both cases large quantities of cattle farms are common. Examples of the importance of dairy farms are the ‘Beemster’ and ‘Gouda’ cheeses which are produced in the vicinity of selected cases (Compendium voor de Leefomgeving, 2015).

Furthermore, the selected cases are interesting for this research since both areas are affected by salinization caused by anthropocentric and climate change influences (de Boer & Radersma, 2011). Also, main case and the exemplary case are managed by different water authorities. Namely, the board of *Hollandsnoorderkwartier* in for Waterland and *Rijnland* for Midden-Holland. These board are the legislative level for water management (Unie van Waterschappen, 2018).

1.5 Problem statement

When concluding the previous paragraphs of the introduction and the theoretical framework the problem statement can be defined. In this paragraph a brief summary of the problems within the characteristics of the: external environment, farmers and the climate-smart agricultural measures are discussed.

Climate changes causes Dutch peatlands to less suitable for farming in the future, as land subsides, and water levels rise. A solution has to be found in order to keep the land for farmers as workable and profitable in the near future. Transforming farmlands to their natural state is not a desirable situation as climate change reduces crop yields and worldwide increasing populations demand for more food. A solution should therefore be found to sustain farming on peatlands while also calculating in the risks and effects of climate change. Farmers are generally willingly to invest in climate-smart agricultural measures as long as they are profitable for their business model.

1.6 Main Research Question

What are the main perspective frames of climate-smart agricultural practices intergraded with current Dutch groundwater management practices?

1.7 Research questions

In order for this research to understand the different stakeholders' perspectives and the possibilities for smart climate agricultural practices to be intergraded with the Dutch groundwater management practices did this thesis design the following questions to guide the research to conclusion

- 1. How is Dutch groundwater managed in the cases in North and South Holland?**
- 2. What climate-smart agricultural practices are applicable for Dutch peatlands?**
- 3. In which ways can climate-smart agricultural practices be integrated in Dutch groundwater management?**
 - 3.1. Which climate-smart agricultural practices are best applicable for Dutch peatlands?
 - 3.2. How the different actors in the peatland playing field experience climate-smart agricultural practices as integrated part of groundwater management?



Understanding of the different stakeholders' perspectives about climate-smart agriculture practices in Dutch peatland areas, intergraded in groundwater

1.8 Reading Guide

Every chapter in this research starts with a reading guide, written in *italics*. This reading guide is a brief summary on the contents of that chapter. The structure of this thesis research is explained in this paragraph. The next chapter explains the theoretical framework, where social constructivism and discourse analysis are important elements for this thesis. Furthermore, a conceptual model shows the schematic flow of the research process. Chapter 3 explains the methodology used for conducting this research. The research strategy in paragraph 3.5 explains how each individual research question was conducted and concluded. Then the empirical chapters of this research follow in accordance with the conceptual model as defined in paragraph 2.3. In chapter 4 the characteristics of the external environment of the selected cases are discussed. The characteristics of farmers and their willingness and possibilities for using new technologies are discussed in chapter 5. While in chapter 6 the characteristics of climate-smart agriculture are explained. As well as the future prospects for the selected cases. Then in chapter 7 the actors in the fields of the selected cases are compared and analyzed. Followed by conclusions and recommendations in final chapter 8.

2. Theoretical Framework

The theoretical framework chapter will elaborate upon the selected research perspective of social constructivism in paragraph 2.1. In paragraph 2.2 the choice of the research method discourse analysis is discussed. This chapter concludes with a problem statement and research questions.

2.1 Social Constructivism

When conducting a study, researchers can apply different interpretive frameworks. These frameworks are derived from the philosophical assumptions of: ontology, epistemology, axiology and methodology. Researchers use frameworks and their theories to help and practice the research process more clearly (Creswell & Poth, 2018). The worldview of “*social constructivism*” was used to conduct this study. Using the worldview of social constructivism in this research helped to place the perspectives of different actors in a broader context.

In social constructivism researchers seek for an understanding of the world in which they live and work. A standard attribute in this constructivism is that the idea of a universal truth which is questioned (Brown, Sorrel, McClaren, & Creswell, 2006). Knowledge is seen as designed and shaped by social interactions in the contexts of within knowledge is created and accredited (Ockwell & Rydin, 2006). In this framework people develop subjective meanings experiences in the world they live in. Often these meanings are so varied and of complex nature, that simply narrowing meanings into concepts or ideas does not do just to the complexity of the discourses (Creswell & Poth, 2018; Kim, 2001). In this research the analysis of the discourses of the three main actors (farmers, legislators and water boards) can only be understood when the interaction between the actors is also analyzed.

In order for the interactions to be fully understood it is important to interview the actors with broad and open-based questions. Open questions force the interviewee to construct the meaning to a situation, rather than simply fabricating an answer in which a situation is merely described (Creswell & Poth, 2018). Apart from social constructivism are other worldviews that are used by researches as a framework in research. Other commonly used metatheoretical frameworks are:

- **postpositivism:** in this metatheoretical framework researchers consent that theories, backgrounds, knowledge and values of the researcher can influence what is researched. Postpositivist researchers use both quantitative and qualitative research methods as ways to conduct research (Phillips & Burbules, 2000);
- **transformation:** is a developing research perspective. This perspective focusses on structuring and facilitating societal learning processes (Wittmayer, Hölscher, Wunder, & Veenhoff, 2017); and,
- **postmodern:** this broad movement involves an extensive diversity of approaches. This makes postmodernism a hard to define framework (O'Donnel, 2003). Nonetheless is postmodernism characterized by: “*broad skepticism, subjectivism, or relativism; a general suspicion of reason; and an acute sensitivity to the role of ideology in asserting and maintaining political and economic power*” (Duignan, 2009).

For this study social constructivism was selected as metatheoretical framework since this framework was able to help explain the complexity of the discourses and the interaction between the actors in Dutch peatlands.

2.2 Discourse Analysis

Discourse analysis is employed to uncover the relations between the actors in the field of agriculture in peatlands.

A discourse analysis derives from the worldview of social constructivism and purposes to critically analyze the ways in which language is used in the given context of smart-climate agriculture (Jørgensen & Phillips, 2002). The assumption discourse analysis makes is that language is not an exact copy of the real world. Instead it helps to shape the world and how we as humans perceive it. Thus, discourse analysis has as foundation that meaning is retained in spoken and written texts. For this research the discourses used in the field of agriculture in peatlands were used to analyze the problem. Nonetheless, are there different ways to interpret and apply discourse analysis in a research. This paragraph will elucidate on these different interpretations. To have a complete understanding on the discourses in the field of smart-climate agriculture in peatlands, both language and discourse in practices, events and actions will be the subject of analysis (Hollemaans, 2015).

In 1972, Pierre Bourdieu, a French theorist, explained structure and agency based on the concept of habitus. In his book '*An Outline of the Theory of Practice*' published in 1972 he described that agents are socialized in a 'field' where various forms of 'capital' are at stake (Bourdieu, 1977). French philosopher Michel Foucault partakes in the same ideas of Bourdieu, however Foucault focuses on the historical processes that shape the way agents think, while Bourdieu focusses on the way we think, which is generated from social structures (Jensen, 2014). The works of Foucault strongly influence the discourse analysis in social sciences conducted by researchers (Fairclough, 2003). Working with the discourse analysis will help to have a complete understanding of the events, practices and structures involved in the field of study (Wagenaar, 2011). However, understanding the discourses in the field of smart-climate agriculture in Dutch peatlands as well required attention to the linguistic features of texts. A discourse analysis is the ideal approach to uncover the meaning of discourses in several forms of communication. In social science research, the works of Foucault strongly influence the way discourse analysis is conducted (Fairclough, 2003; McHoul & Grace, 1993).

In discourse analysis there are many forms and methods for analysis (Van Dijk, 2011). All these different forms of analysis can be categorized in two main approaches. One in which there is a detailed inclusion of analysis of texts and one that does not include this. Emeritus Professor of Linguistics Norman Fairclough used text analysis as an essential part in discourse analyses. In this research the analysis of texts and written words are both important for an overall understanding of the discourses in Dutch peatlands (Fairclough, 2003).

Texts and social agents

In social sciences there is an ongoing debate by scientists and researchers, about the primacy of the concepts of structure and agency. In which structure is the patterned arrangement which determines of limits choices and opportunities for agents. And where agency defines the capacity of an agent to act independently and make self-determined decisions (Barker, 2003). The ongoing debate centers on the issue whether or not agents are able to act individually and independently, or whether they are structured by social powers.

In discourse analysis social agents are not 'free' agents, as they are socially constrained. Yet, the actions of agents are not completely dependent on social structures (Fairclough, 2003). This is because agents have powers which are different from the causal powers of social structures. For example, agents can texture parts of texts and can make

relations between texts. Structural constraints are more influential on texts than social structures and practices. Grammatical forms in language determine the way social events and texts are to be organized, as erroneous grammar causes for a structural constrained in language. Nonetheless can agents obtain their freedom in texturing texts from for example an interview, thereby the agent is part of the making of meaning (Fairclough, *Analysing Discourse: Textual analysis for social research*, 2003). Meaning might not be pre-existing but is derived from discourses in words and expressions. The meaning from the combination of different texts are helpful in analyzing the discourses in the field of smart-climate agriculture. The discourse analysis by British social linguist Normal Fairclough is a well-developed method for using the discourse analysis (Wagenaar, 2011).

In general, we can say that ways of acting and interacting can be done through three distinct social levels, namely: events, practices and structures. The relationship between these three were important for understanding the discourses in this thesis (Fairclough, Jessop, & Sayer, 2001).

Social events

Social events have a complex symbiotic relation to the social structures. As it is not easy to define the ways in which events influence structures. Texts however are considered the main element in this social level. Within texts is language the modelling feature in the shaping of texts. *“texts are not just effects of linguistic structures and orders of discourse, they are also effects of other social structures, and of social practices in all their aspects”* (Fairclough, 2003, p. 25).

Social practices

In sociology social practices pursue to determine the relationship between the practice and the framework of social situations. This concept is usually applied in the context of human development (Smolka, 2001).

Social structures

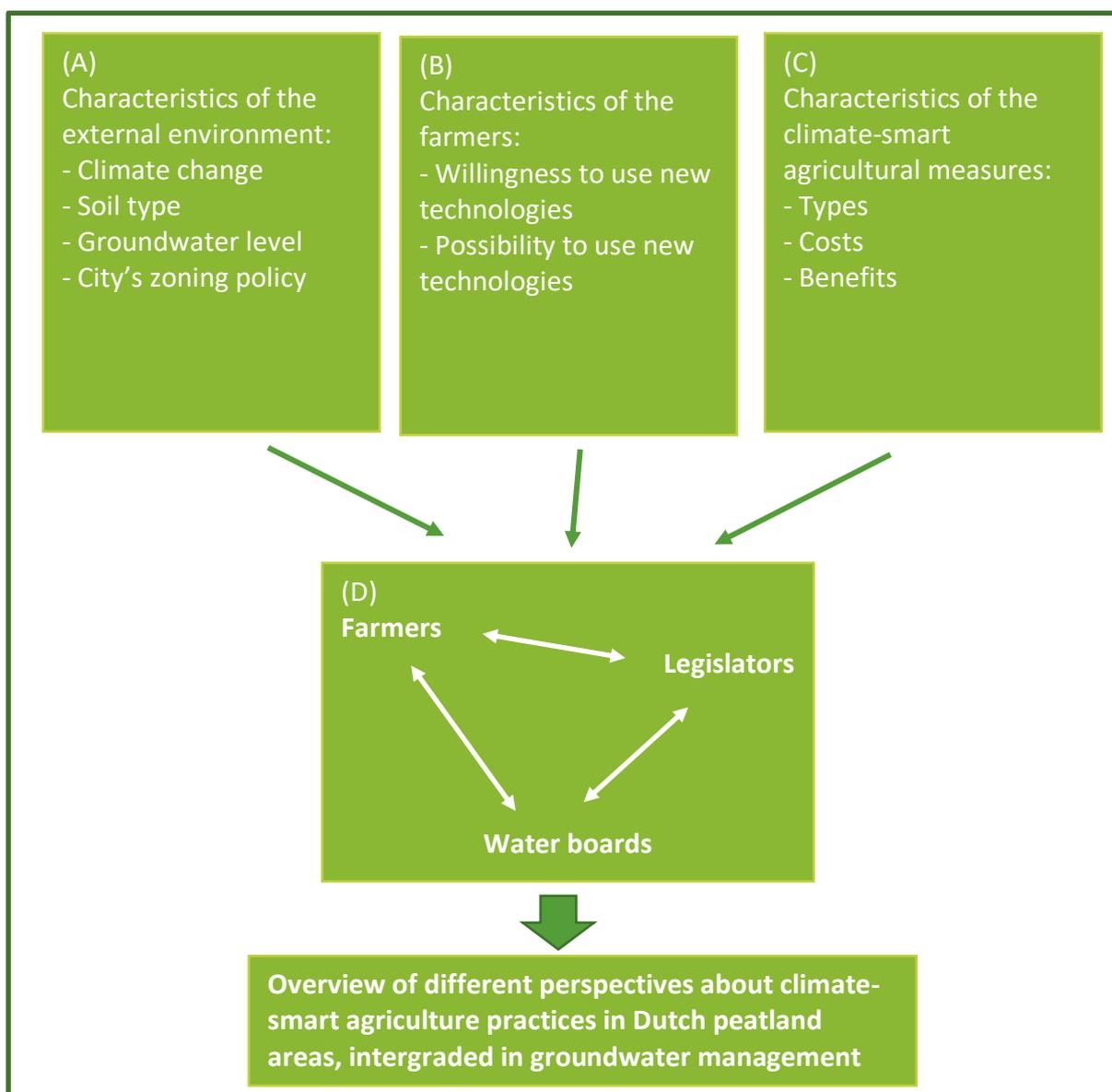
Social structures are considered by many sociologists to have a very abstract nature. This is because the relationship between what is possible and reality among events and structures is a very multifaceted. Language is considered to be the main contributor to the abstractness of the relationships between structures. As linguistic elements can define possibilities but can also be used to exclude others (Fairclough, 2003; Peirce, 1995; Wagenaar, 2011). Language is overdetermined in these three social elements.

Paragraph 3.3 will explain the different steps in discourse analysis that were conducted and were these steps are implemented in this thesis.

2.3 Conceptual model

A conceptual model shows, schematically, how the relationships between the actors and the key concepts are perceived. The conceptual model of this research should represent the relationships of farmers, legislators and water boards in this research. Some relationships in this model are suggested as the conclusion at the end of this research will further specify the relations between the actors involved in this thesis research. In conducting this qualitative research, the variables that intervene in the suggested relationships between the actors will become clear. Eventually this will lead to an overview of the important concepts that are influential in the playing field of this research (Verschuren & Doorewaard, 1999).

A paper by S.S. Meijer, D. Catacutan, O.C. Ajayi, G.W. Sileshi, & M. Nieuwenhuis (2015), into the innovations among smallholder farmers in sub-Saharan Africa used a framework which proved to be very helpful in designing a conceptual model for this research. In this research the uptake by smallholder farmers to use new agricultural technologies was analyzed, since this uptake seemed to be rather slow. The conceptual model as seen below is based on the ideas in the analytical framework of that research paper.



Within this framework the three distinct social levels as mentioned in paragraph 2.2 are integrated. After describing the characteristics of the several research elements (A,B,C) the acting and interacting between the actors are analyzed (D). Farmers, legislators and water boards are in section (D) analyzed based on: social events, social practices and their social structures (Fairclough, Jessop, & Sayer, 2001).

3. Research Methodology

This chapter elaborates upon the selected methodology for this research. In paragraph 3.1 the research strategy methods are explained. Paragraph 3.2 explains the chosen “explanatory case study” as approach in this case study research. In accordance with the discourse analysis explained in chapter 2, the steps of discourse in this research are discussed in paragraph 3.3. Paragraph 3.4 explains the research materials used in this research and finally in paragraph 3.5 the research strategy explains how each individual research question was conducted and concluded.

3.1 Research Strategy Methods

The research period was conducted during the 3rd and 4th semesters of the Radboud University academic year of 2017-2018. This involves the months March till early August 2018. This research is part of the bachelor thesis for the researcher Thomas Kamphuis. The final deadline for the thesis is Friday 17th of August 2018. And the strategy used in research is that of an explanatory case study.

This research will use qualitative methods as an approach in this thesis-research. In this research the researcher tries to define the opportunities of long term climate adaptation for Dutch agriculture in peatlands. Qualitative methods are then a good approach as it combines literature, field studies, audiovisual sources and interviews for data collection and analyzation (Creswell & Poth, 2018, p. 160). This research will use a field research into the experiences different actors have in the playing field of this research. Using qualitative methods is then the ideal research methodology (Verhoeven N. , 2011, pp. 29-31). This research will focus on two research areas, namely the cases Waterland and Midden-Holland. These cases will be used to extrapolate the results of these findings for the usage in other cases. Adding to this is a case study characterized by more in-depth research (Verschuren & Doorewaard, 1999). In this research, the depth is obtained by various methods including: a detailed observation of the project area, interviews with key actors and desk research into existing literature. This triangulation of methods and sources is an important part of this research.

In a case study the following steps should be used in order to successfully conduct a research (Creswell & Poth, 2018, pp. 97-102):

1. determination if the cases of Waterland and Midden-Holland are suitable for to illustrate the issue of long term climate adaptation for Dutch agriculture on peatlands;
2. identify the intent of the study;
3. developing of procedures for conducting extensive data;
4. specifying the analysis approach; and,
5. Reporting the case study and lessons learned by using case assertions in the written form of this thesis research.

The following paragraphs will elucidate on the five steps mentioned.

For this research I will use the previously mentioned five steps by Creswell and Poth (2018). These steps are blended in this research and function as backbone of the research structure. The table below will show these five steps and how this thesis used them to conclude the research.

Steps by Creswell and Poth (2018)	In accordance with chapter in this research
1 determination of cases	Chapter 1 in this research elaborates upon the determination of cases. Paragraph 1.5 described that ' <i>Midden-Holland</i> ' is the main case and that the case of ' <i>Waterland</i> ' is used to define important differences or similarities that are
2 identify the intent of the study	The intention and necessity of this research is described in paragraph 2.6
3 conducting extensive data	Chapter 2 in this research gives a first overview of the know data and current researched that involved agriculture in Dutch peatland areas.
4 analysis approach	In chapter 3 the methodology of the research is explained. Chosen was for a collective case study approach as it proved to be the most helpful for this research. Chapters 4,5 and 6 analyze the characteristics of the cases
5 reporting the case study	This case study is reported in the shape of this research thesis. Chapters 4,5 and 6 are the core of this thesis as they discuss the results. Chapters 7 and 8 report the conclusions, recommendations and the discussion of this thesis.

3.2 Explanatory case study

There are different types of case studies that can be used as research strategy. These three types are: *single instrumental*, *collective and intrinsic* case studies. In a single instrumental case study, the researcher focusses on a selected issue or concern and then selects a confined case to elaborate on the issue. In an intrinsic case study, the researcher focusses on one specific case as this case represents an exceptional or unusual situation. In the collective case study strategy, a single issue or concern is selected, and the researcher uses multiple cases to illustrate the issue (Creswell & Poth, 2018, pp. 98-99). Since this research is looking at long term climate adaptation for Dutch agricultural in peatlands and uses two cases and their actors to elucidate on the issue, is a single case study the research strategy chosen in this research. Since, a single-case study is used in this thesis to pursue an explanatory purpose (Yin, 1994). Because in this single-case study the explanatory purpose is so important, American social scientist, Robert K. Yin (1994) an "*Explanatory Case Study*" to be the best description of the type of case study research used in this research.

3.3 Steps in Discourse analysis

University lecturer and social science and area studies scholar Florian Schneider (2013) developed a series of ten steps to help conduct a systematic and professional discourse analysis, based on the works of Norman Fairclough. The table below shows the steps and the description of them by Schneider (2013), the right column shows the corresponding paragraphs in this thesis, in which these steps are elaborated upon.

Step	Description	Corresponds with paragraph x in this thesis
1	Establish the context of the research and how this research fits into the broader context of the case itself.	§ 1.1
2	Explore the production process: an institutional background research into additional information and sources about the context. Adding to this is it important to determine the medium of the media. Some scholars argue that the medium in which articles or sources are produced contribute to the way it is perceived.	§ 2.7
3	Prepare your material for analysis: in order to analyze the written words, the researcher should prepare it in a way that allows the researcher to work with the source, elaborate on details, and make precise references later.	Chapter 3
4	Code your material: assign attributes to specific units of analysis. Paragraphs, interviews, quotes and individual words should be coded into different categories. The categories used in one's research depend on the selected topics and cases. The tools used for coding can be both digitally and by-hand using highlighters and markers on printed works.	§ 3.6
5	Examine the structure of the text: after coding the sources that were needed for this thesis research it is important to study the structural features of the analyzed texts and interviews.	Chapter 5,6 & 7
6	Collect and examine discursive statements: by looking into the individual statements by the involved actors in this thesis, is the researcher able to map out what "truths" the text founds on research question.	Chapter 4,5 & 6
7	Identify cultural references: how does the context informs the argument. By collecting all statements made by the actors in the selected research case the researcher is able to figure out the intertextual functions that serve the overall argument.	Chapter 7
8	Identify linguistic and rhetorical mechanisms: in this step the researcher identifies the function of various statements made by individual actors in this research. This is conducted by looking at: word groups, grammar features, rhetorical and literary figures, direct and indirect speech, modalities and evidentialities. (Schneider, 2013).	Chapter 7
9	Interpret the data: when all information and data is gathered it is important to define the truths and the definitions of all the gathered information. An important question to ask here is: <i>'who might benefit from the discourse that your sources construct?'</i>	Chapter 7
10	Present your findings: presenting the findings by stressing the relevance of the thesis research and to focus on making a compelling case.	Chapter 8

Table based on the work of Schneider (2013)

In a social-constructivists research, discourse analysis implies that the researcher should be closely involved in the case that is being researched (Milliken, 1999). In this research this is reflected by the objective set for this research, by providing an overview of different perspectives about climate-smart agriculture practices in Dutch peatland areas. Thus, the researcher contributes to the development of the discourse. This research will analyze the discourses between: farmers, water boards and municipalities using this discourse analysis. The conceptual model in the next paragraph will elucidate on the relationships between actors and this thesis research.

3.4 Research Material

This research is conducted mainly by doing desk research. This desk research includes sources from the Radboud University library, both online and physical. Online searches were conducted by using search engines from the Radboud University using a VPN connection¹ to access library sources at home. RUquest and Google Scholar were the preferred search engines in this research. All sources are listed in the bibliography at the end of this thesis using APA 2016 guidelines.

The quality of sources is really important for a reliable and sound thesis research (Verhoeven N. , 2015). Therefore this research selected sources based on either: usability, validity and reliability. Below a brief description is given on how the quality of sources is checked.

Usability

The usability of a source is based on the outcomes and conclusions of a certain source. A source might not be reliable due to errors or outliers, yet the usability of data can help make certain fields of study clearer (Swean, 2014).

Validity

Validity of a research is defined by how well a research truly measures what it is claimed to measure (Golafshani, 2003). Validity however, is more applicable to quantitative research as it shows how information randomly gathered from samples is valid for the actual populations. Not many quantitative sources are being used in this research, as they are not applicable for the researched cases. Nonetheless, this thesis validated sources based on their reliability.

Reliability

A research is considered reliable if the results of the study can be reproduced in another research using the same methodology as the research in question (Golafshani, 2003). Replicability or repeatability are important concepts for a source to be reliable (Verhoeven N. , 2015; Verschuren & Doorewaard, 1999). In this research this is checked by using the so called “*anchor links*”² of search engines. This function shows the amount of times a source is cited in other works that were published in journals or books. For this research sources were selected with a minimum of five times being cited in other works, to increase the reliability of the sources. In single cases a minimum of five times cited could not be verified. If the source was still useable or valid, was it added as reference or source.

Apart from desk research, in-depth interviews were held to find out more about the discourses between farmers, legislators and water board. Also, these interviews proved

¹ VPN connection: or Virtual Private Network, is a secure connection to another network on the internet, in this case a connection to the network of the Radboud University (Hoffman, 2018).

² Anchor link: a link within a website that connects to another hyperlink, that in this case shows the amount an article is cited (w3schools, 2018).

helpful in the understanding of the researched cases. Paragraph 2.5 discussed the stakeholders involved in this research.

Interviews

This thesis conducted a series of two interviews. The questions are conducted using semi-structured interviews. Semi-structured interviews contain a topic list and some questions to be asked by the interviewee in question. This style of interview lets the researcher be flexible in the style of data gathering. The interviewer is then for example able to ask follow-up questions or ask for more details in a given answer (Verhoeven N. , 2015). Annexes 1 and 2 show more detailed information about these interviews, including the topic/questionnaire list which was used to conduct the interviews.

3.5 Research strategy

	Sources + keywords	Required information	How was the information obtained?	Result
Research question 1	Interview with Walter Kooy, official in general board of Hoogheemraadschap De Stichtse Rijnlanden <u>Library- and internet research:</u> water boards Hollands Noorderkwartier and Stichtse Rijnlanden, laws and regulations South/North Holland	General overview/list of (inter)national laws and regulations that apply for the cases in the Netherlands. Walter Kooy provided information about the current and future position of the water boards in the case areas.	By using a semi-structured interview, a questionnaire together with a topic list, resulted in the answering of the research questions. The interview left some space for the interviewee's own input about the future scenarios for climate -smart agriculture (Verhoeven N. , 2011). Elucidating on Kooy's own ideas and thoughts about the future of agriculture in peatlands were important in this interview.	Overview of characteristics that shape the external environment, in accordance with part (A) in the conceptual model, mainly focused on the water boards point of view.
Research question 2	Interview with Erik Jansen, board of the Peatland Innovation center in Zegveld. <u>Library- and internet research:</u> climate-smart agriculture, new technologies and innovations in peatland agriculture, climate change agricultural adaptations, Dutch future agriculture prospects.	Overview of the types, costs and benefits for climate -smart agricultural measures for Dutch peatlands.	By using a semi-structured interview, a questionnaire together with a topic list, resulted in the answering of the research questions. The ideas and thoughts of Erik Jansen were the most important as these resulted in the best applicable measures for new types of agriculture in Dutch peatlands.	Conclusion of climate -smart agricultural measures that are best applicable in Dutch peatlands. This in accordance with parts (B) and (C) in the conceptual model.

Research question 3.1	Interview with Erik Jansen, board of the Peatland Innovation center in Zegveld. And a quick questionnaire with farmers located in the cases.	Perspectives about climate - smart agriculture applications for Dutch peatlands in the future.	By using a semi-structured interview with Erik Jansen and a questionnaire with farmers gave intel about the preferred future situation of Dutch peatlands and how agriculture should then be executed.	Conclusion of climate -smart agricultural measures that are best applicable in Dutch peatlands, based on farmers preferences. This in accordance with parts (B) and (D) in the conceptual model.
Research question 3.2	Outcomes and results from questions 1,2 and 3.1 <u>Library- and internet research</u> : perspectives on climate change, future perspectives on farming in the Netherlands, discourses in Dutch agricultural practices.	Perspectives about climate - smart agriculture applications for Dutch peatlands in the future. The pros and cons played against each other in these perspectives are important.	The internet and library research helped to narrow down the researched solutions. The solutions were the result of the previous research questions of this research.	Conclusion of how climate - smart agriculture can be integrated in future Dutch groundwater management, resulted in the main perspective frames of the actors involved. This in accordance with parts (D) in the conceptual model.

3.6 Data analysis

Analyzing tools

As mentioned in previous paragraphs in this chapter, this research is conducted mainly by doing a desk research and by conducting two interviews. All of this data was analyzed using the qualitative data analysis and research software “ATLAS.ti”³. This software was chosen because ATLAS.ti offers possibilities to process diverse types of sources of information gathering. Analyzing data with this software is conducted by the coding of texts in the transcription of the interviews. Coding is more than just organizing masses of data. The analytical step of coding helps the researcher to “*elevates this particular instance of empirical reality to a higher level of conceptual abstraction*” (Wagenaar, 2011, p. 261). By organizing the codes, the data can be organized by creating conceptual connections of which the researcher could have been unaware (Wagenaar, 2011).

This research based its codes on the guiding research questions. The main codes in this thesis research helped to create categories, that both described and explained the data (Wagenaar, 2011). The table on the next page gives an overview of the main codes, which are derived from the research questions. For this research the main codes were derived from the

³ More information on ATLAS.ti can be found online on <https://atlasti.com>

research questions, some codes have an overlap with other research questions such as “*future perspectives on farming in peatlands*”. Within the main codes, as seen in the table below, sub-codes existed which explained the main code in more detail. For example, the code “*Laws and regulations*” contained codes of *local, national and international* laws and regulations.

Coding was also applied for the desk research, but not in every case the ATLAS.ti software was used. All of the literature was copied, or printed, and notes and codes were written by hand on each source. Sources were then placed in order of each code, as described earlier, and were then added into this thesis as source, taking in account the usability, validity and reliability as mentioned in paragraph 3.4.

Research question/topic	Main codes
Research question 1	<ul style="list-style-type: none"> • Laws and regulations • Waterboard’s perspective on farmers • Waterboard’s perspective on climate-smart agriculture • Future perspectives on farming in Peatlands • Tools for improvement • Groundwater management
Research question 2	<ul style="list-style-type: none"> • Climate-smart agriculture • Climate-smart agriculture in Dutch peatlands • Costs and benefits • Stressors in Climate-smart agriculture • Underwater drainage systems • Characteristics of Climate-smart agricultural measures
Research question 3.1	<ul style="list-style-type: none"> • Future perspectives on farming in Peatlands • Characteristics of the external environment • Characteristics of Farmers
Research question 3.2	<ul style="list-style-type: none"> • Perspectives about climate-smart agriculture applications
Theoretical Framework	<ul style="list-style-type: none"> • Discourse analysis • Social constructivism • Conceptual model

Interviews

The interviews were conducted using a simple guide. In order for the interactions to be fully understood it is important to interview the actors with broad and open-based questions. Moreover, are the open-based questions important to define the definition on new concepts, for example new technologies as the underwater drainage systems in this research (Verhoeven N. ,2011; Creswell & Poth, 2018). Open questions force the interviewee to construct the meaning to a situation, rather than simply fabricating an answer in which a situation is merely described, therefor an open-based questionnaire was used based on the sample of J.W. Creswell and C.N. Poth (2018, p. 167). The questionnaires of this research can be found in annexes 1 and 2.

All interviews were recorded with permission from the interviewees. These recordings were later transcribed. A transcription of the interview and the notes taken during the interview were afterwards shared with the interviewees. Not any comments or changes were added after the transcription was shared with any of the interviewees.

3.7 Stakeholder Analysis

A stakeholder analysis is an important tool for creating an overview of stakeholders and seeing which opportunities are possible for a researched goal (Varvasovszky & Brugha, 2000). For this research the characterizations of each stake holders were mapped to importance of stakeholders needs relative to other stakeholders in the field. This method was designed by Cameron, Seher en Crawley in their paper: *“Goals for space exploration based on stakeholder value network considerations”* (2011). Their analysis is in accordance to two principles:

1. *“Establish and prioritize the needs of a given stakeholder based on the importance to them”*; and,
2. *“Establish and prioritize the stakeholders based on their importance to the organization”*, in which the organization in this thesis research is the case of Midden-Holland (Cameron, Seher, & Crawley, 2011).

The paper by Cameron, Seher en Crawley (2011) explains that the two principles, as mentioned above, suggest that the discourses between actors result in fundamental information needed in research. Mapping the stakeholders is successful when the exchange between the *“outputs of the project meet the needs of the beneficial stakeholder, and the outputs of the beneficial stakeholder meet the needs of the project”* (Cameron, Seher, & Crawley, 2011).

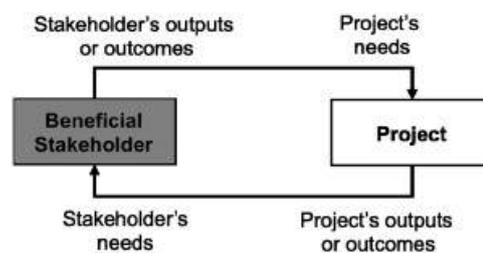


Figure 5: A simplified exchange of benefits between stakeholders (Cameron, Seher, & Crawley, 2011).

Figure 5 shows a simple exchange of information in a simplified two stakeholder transaction. In the case of this thesis research another stakeholder needs to be added since this research works with three distinct stakeholders. Nonetheless, is the scheme in figure 5 useful for this research as it shows the continuation of exchange of needs and outcomes between stakeholders. As to establish an exchange between the stakeholders Cameron, Seher en Crawley (2011) defined that it is important to characterize the needs of the individual stakeholders first. The table on the next page explains the needs of the stakeholders in relation to the selected cases.

Stakeholder	Needs
Legislators (Municipalities)	Comply with European and National Legislation. In which environment, sustainability, living environment, water safety and the local economy are key in their legislation (Vereniging van Nederlandse Gemeenten, 2018). Legislators on municipal level arrange their policies based on local issues and opportunities.
Farmers	A profitable business, based on of the two main business models, namely: intensive agriculture and adaptive agriculture. (Jansen, Personal Communication, 2018; Woestenburg, 2009). Continue reading about this in paragraph 4.2.
Water boards	Complying with National regulations and safekeeping of Dutch water levels and qualities. The water boards of Stichtse Rijnlanden en Rijnland defined that water needs to be in good condition for a healthy ecological condition for a body of water. Yet because of practical, economical or societal demands the water board can deviate from its original goal of providing healthy ecological conditions for water. A bar chart of five levels was defined, which shows the qualification bodies of water receive based on the condition of the water and in what ways is deviated from the original standard (Hoogheemraadschap van Rijnland, 2018).

4. Characteristics of the external environment

In this chapter the characteristics of the external environment of the cases are explained. Paragraph 4.1 zooms in on the stakeholders involved in this research. And paragraph 4.2 looks at climate-smart agriculture and defines several forms of measures that can be implemented in Dutch peatlands.

4.1 Stakeholders

As seen in the conceptual model in paragraph 2.4 the three main stakeholders for agriculture in peatlands are: legislators (municipalities), farmers and water boards. Municipalities, farmers and water boards are the actors that will provide the best insights for this research, as they are the key players in the case of agriculture in peatlands. The following two stakeholders were interviewed in this research:

Stakeholder	Interviewee
Farmer/Legislator	Erik Jansen, Peatland Innovation Center (Zegveld Veenweiden Innovatiecentrum)
Water boards	Walter Kooy, official in general board of Hoogheemraadschap De Stichtse Rijnlanden

The research of van Doorn, et al. (2017) at the Wageningen University and Research, proved very helpful as it contained detailed information about farmers perspectives for new technologies in Dutch peatlands.

4.2 Climate Change

Climate change is changing the way Dutch groundwater is managed and will affect water qualities, as saline intrusion is seeping in to ground and open waters of Dutch peatlands (Oude Essink, van Baaren, & de Louw, 2010). Moreover, a continuing of global warming will further endanger ecosystems in the world, including peatlands, as rising temperatures and increasing sea-levels trigger negative changes in ecosystem behavior (Steffen, et al., 2018; Erwin, 2009). Climate scenarios predict that deltaic environments, like Dutch peatlands, are in grave danger of flooding and damage by coastal storms as soon as the end of this century (Steffen, et al., 2018).

4.2.1 The Knowledge for Climate research program

From 2007 till 2014 a research program in the Netherlands looked into the field of climate change and adaptation. This research program was called 'Knowledge for Climate'. The involved partners in these researches were: Wageningen UR, Utrecht University, the VU University Amsterdam, KNMI, TNO and Deltares. The background ideas of the program were that even if anthropocentric activities were drastically altered, direct and indirect effects will affect natural ecosystems (Knowledge for Climate Foundation, 2014). It is these indirect effects that are of importance as these are crucial for interactions in climate change forecasting. Indirect effects are crucial since the potential effects on the environment are hard to predict (Shuttle, Thomsen, & Power, 2007; Friedland, Relyea, & Courard-Hauri, 2012). For long term political decision-making to be sustainable, is it necessary for climate change needs to be incorporated. The Knowledge for Climate addressed the consequences of climate change, by using applied research and developed scientific knowledge within eight research

themes. To elucidate on these themes eight different cases were used in the Netherlands, that were most vulnerable for the effects of climate change. (Knowledge for Climate Foundation, 2014). The following eight research themes were used:

1. Climate Proof Flood Risk Management;
2. Climate Proof Fresh Water Supply;
3. Climate Adaptation for Rural Areas;
4. Climate Proof Cities;
5. Infrastructure and Networks;
6. High-quality Climate Projections;
7. Governance of Adaptation, and
8. Decision support tools.

This research will use the theme Climate Adaptation for Rural Areas from the Knowledge of Climate research program. Within this theme the researchers looked into the responses of nature to climate change. For this research it is important to see different discourses of the involved stakeholders in rural peatland areas. By designing and using climate models in the researched cases it was made possible to simulate how nature is functioning in diverse Dutch climates (Driessen, et al., 2015). Using the theme of Rural Areas by the research program will aid as foundation in this thesis.

The peatlands in the western part of the Netherlands are currently developing in three different directions:

1. Large scale agriculture with the focus on production for the global market. Upscaling and structural improvement are important in this direction;
2. Urban agriculture, in which farmers focus their produce and services to that of local citizens. Farmers do this by caring for landscape, water and nature, so called '*green-blue services*', and
3. Nature-farming (in Dutch: Natuurlandbouw) in which the revenue models of farmers is partially focused on the management of natural areas (Woestenburg, 2009).

4.2.2 Climate scenarios

Designing scientific climate scenarios are an important tool in policy analysis for climate change. These scenarios have become vital in projections of climate and socio-economic futures since they represent uncertainties in complex, dynamic systems (Berkhout, et al., 2014; Haasnoot, Schellekens, Beersma, Middelkoop, & Kwadijk, 2015). A key issue in the creation of most climate scenarios are these uncertainties in weather and climate projections. This is because a key debate amongst scientist is about the ability of models to predict extreme climates. Optimism arises as these scenario models can predict so called '*tipping points*', such as the effect of large deforestation in the tropics, which are aiding in providing warming systems (Maslin & Austing, 2012).

Even though there is an abundance in scientific data providing information about the negative effects of anthropocentric activities on the global environment, there is a deficiency of environmental policies. It is important to start protecting the environment, so a sustainable society is able to sustain long-term welfare for humanity, (Kopina, 2011). Moreover, the negligence in public debate and scientific uncertainties are justification for indecisiveness in environmental policies.

“The biggest obstacle is the unwillingness of politicians to act in the long-term interests of society” – Maslin & Austing (2012)

The complex interactions of discourses, concerning: (emerging) technologies, society, globalization and the environment, are seen as additional hindering factors (Mercure, Pollitt, Bassi, Viñuales, & Edwards, 2016). Nonetheless is enough evidence and data available to be the base for environmental policies, national governments need to act to start a change for environmental improvement (Maslin & Austing, 2012).

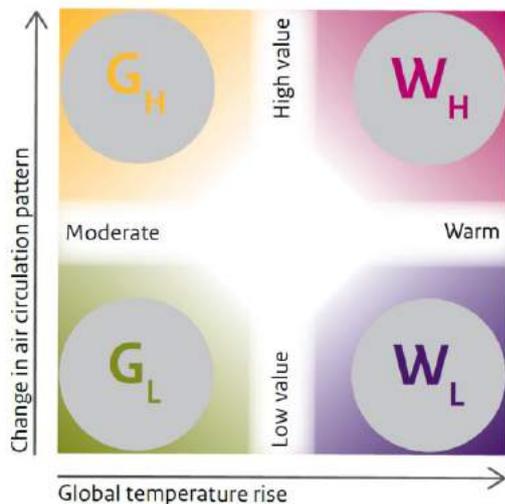


Figure 6: Schematic overview of the four KNMI'14 climate scenarios (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015, p. 7).

In the Netherlands the Royal Netherlands Meteorological Institute (KNMI) is the leading service in providing information and (scientific) data concerning: weather forecasting, monitoring of climate changes and monitoring of seismic activities (KNMI, 2018). Safety assessments and advisories of the KNMI are used by many actors in the Netherlands and is the leading weather safety issuer for Dutch governmental services. In May 2014 the KNMI published climate scenarios based on scientific information provided by the IPCC⁴ on climate change. The climate scenarios derived from the IPCC were translated into the 'KNMI'14 climate scenarios'. Four combinations of two values defined the scenarios used in the KNMI'14 scenarios. Temperature, defined by moderate and warmer temperature rise, and air-circulation-patterns defined by lower and higher values,

are the decisive distinctions in the creation of the four scenarios (see figure 6). Key themes in these scenarios are: precipitation, sea-level, temperature, wind and storms, visibility, clouds, solar irradiation and drought (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015). The climate scenarios of KNMI report in 2014 will be revised in 2021. At this moment the Dutch KNMI is working on a project to change or update the scenarios, based on data of the Sixth Assessment Report by the IPCC, to be delivered in 2021. Below a brief summary on the effects on temperature, precipitation and sea-level in all of the scenarios described by the KNMI'14 report.

Temperature

In every scenario average temperatures in the Netherlands will rise in the coming century. This results in less days with temperatures below freezing, as in 2050 it is expected to have less than 5 days of complete freeze during winter. And summer will experience more warm days where the temperature is above 25°C. Extreme cold temperatures are significantly less possible to occur in contrast to extreme warm temperatures. The quantity on the periods of droughts during the spring and summer seasons will increase in the future (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015).

Precipitation

Precipitation levels in all seasons are likely to occur in all climate scenarios. Summer seasons however experience more drought and evaporation as average temperatures increase. Extremes patterns of heavy precipitation will also occur more often in all seasons also as an

⁴ IPCC or Intergovernmental Panel on Climate Change is a leading scientific and intergovernmental body for the assessment on climate change **Invalid source specified..**

effect of rising temperatures (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015).

Sea-level

Sea-level rise is an important issue for the Netherlands as many large parts of the country are below/around sea-level. The main causes of the sea-level-rise are: the global melting of glaciers and icecaps, and the thermal expansion of water cause for a change in density forcing sea-levels to rise. Note that in this scenario the subsidence of peatlands has not been taken in account, meaning that not all risks of sea-level rise on peatlands are taken into account. By the end of this century the sea-level rise is predicted to be between 25-85 centimeter. Even in the distant future increasing temperatures and the melting of icecaps will continue to cause for a sea level rise which can be up to several meters in the coming centuries (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015). Figure 7 shows a graph with the sea-level rise in cm with the Amsterdam Ordnance Datum as baseline.

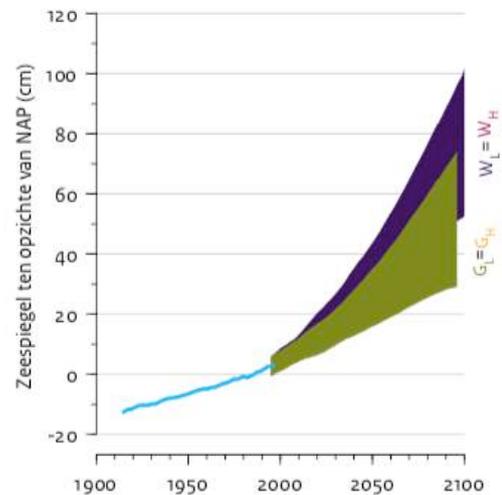


Figure 7: Sea-level-rise in cm, compared to the Amsterdam Ordnance Datum (NAP) In every climate scenario the sea-level will rise with at least 25 cm compared to today's levels (Klein Tank, Beersma, Bessembinder, van den Hurk, & Lenderink, 2015, p. 15)

4.3 Soil Type

The Food and Agriculture Organization of the United Nations (FAO) developed a supra-national classification for soil types. Soil Classification by the FAO involves the grouping of soil types with a similar range of qualities (chemical, physical and biological). The groupings are then geo-referenced and mapped for United Nations data (FAO, 2018). Dutch Peatlands are classified by the FAO as a 'histosols' (FAO - Unesco, 1997). Peat soils (or histosols) in the Netherlands are classified as that within 80 centimeters of soil depth at least 40 centimeters contains of thick organic soil material (Berendsen, 2008b). In 1966 the center for agriculture publications and documentations in Wageningen, the Netherlands, defined over 30 different sub-categories in Dutch peatlands (de Bakker & Schelling, 1966).

For the cases in this study the differences in soils types are the result of past and current land uses. Originally peatlands were naturally drained by existing streams and rivers. The areas were so vast that one was only able to reach peatlands through these small streams and rivers. The first settlements in these peatlands were founded near the quays of these small streams. Around the year 1500 peatlands were drained using windmills, draining even larger areas of peatland. The famous Beemster area in the province of North-Holland was drained in 1609. In the industrial revolution steam engines (later diesel and electric engines) helped to maintain water levels in large sections of Dutch peatlands. Also, these engines helped to drain even more water surfaces (Berendsen, 2008a; Berendse, 2011). The Dutch call these drainage areas "droogmakerijen". Nowadays water boards control and maintain water levels in these peatlands (Hoogheemraadschap van Rijnland, 2018).

The drainage of peatlands resulted in different soil compositions. Differences in compositions are mainly the result of: oxidation, reclamation of land and the mixing of peat with subsoils (Berendsen, 2008a). Peatlands in both cases house countless small streams and rivers as these streams help to drain the land and transport excess water to sea. Because of drainage these waterways help to drain the land and no new sediments are deposited on peatlands. Because these small rivers have a different soil composition are small streams and rivers not subsiding at the same rate as the peatlands around. This results in streams which are located higher than the surrounding peatlands.

As mentioned are current agricultural practices mainly focused around cattle farming. However, in some drained areas the cultivation of flowers (e.g. Dutch Tulips) are quite common. Mainly in the province of North-Holland is flower cultivation an important agricultural product.

4.3.1 Midden-Holland

In the case of Midden-Holland much of the soil originated from sediments brought by the river Rhine; as well as flooding from the North-Sea, which deposited layers of clay derived from seawater sediments. Small layers of clay are thus trace-able in the composition of the peat soils in Midden-Holland. (Berendsen, 2008a). Small branches of larger river streams deposited sediments mainly consisted out of clay. Figure 8 makes shows schematically that almost all of the case area has peat soils as categorized soil type. More specifically the peatlands around Gouda are called “bosveen”. Characteristics of the peat type bosveen is that this peat type was not suitable to use as fuel for heating. Therefore, compared to other types of peatlands in the province, these areas were not used for the harvesting of turf (Berendsen, 2008a).

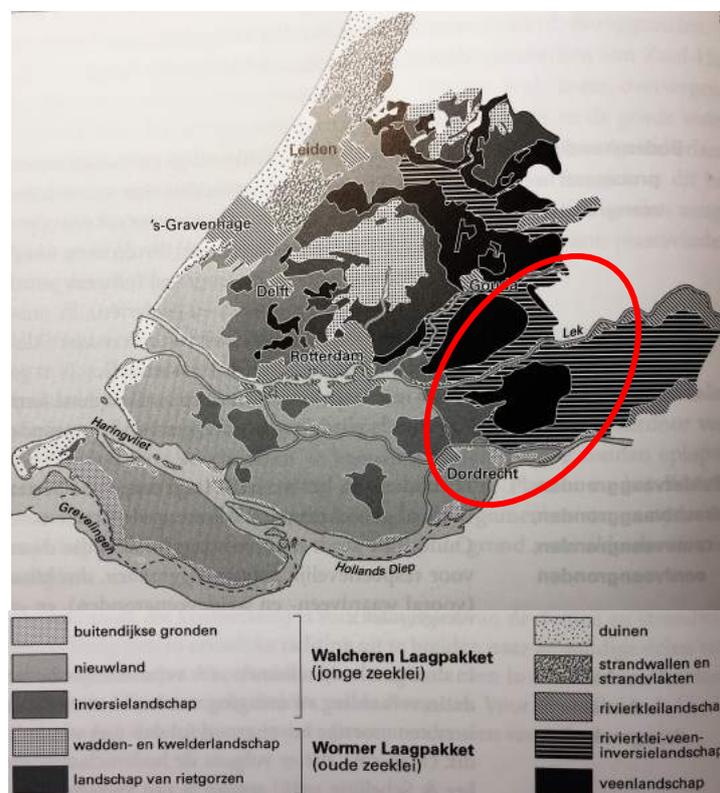


Figure 8: this map shows the soil compositions for the province of South Holland. Important here are the areas in black which show peatlands and the black-and-white striped areas which mark river clay and peat deposits. The research case is located within the red circled area (Berendsen, 2008a).

4.3.2 Waterland

In contrast to *bosveen* which is the common peat type in Midden-Holland, the region of Waterland consists more of *“mosveen”*. *Mosveen* proved to be an excellent source of fuel and was extensively harvested. This overharvesting resulted in the area transforming to large water puddles useless for any other function. Already with windmills these areas were drained to create agricultural land (Berendsen, 2008a). As in the case of Midden-Holland most of the land in this area is mostly used for cattle-farming (Stortelder, et al., 2001).

4.4 Zoning Policies

Zoning policies in this research shall focus mainly on the authority level legislators have on agriculture in Dutch peatlands. Article 3.8 of the Dutch Waterwet, strictly regulates the authorizations on all tasks related to water management. Although differences per location, the law regulates the duties of care for rainwater and groundwater management. In general, the municipality is responsible for the collection of wastewater, rain and groundwater. The water boards are responsible for the treatment of municipal wastewater. Each municipality has their own sewage plan which describes municipal regulations on water management. If water boards are implementing new infrastructure municipalities are obliged to cooperate to secure water safety (Kenniscentrum Infomil, 2018b).

Laws and regulations in peatlands

On regional, national and international level legislators try to maintain and improve the quality of wetlands and peatlands. For the selected cases these levels correspond to European, Dutch (water boards) and municipal levels of legislation. Depending on the spatial scale, different laws and regulations are implemented (Roelsma, Kselik, & de Vos, 2008).

Important on European level is the Water Framework Directive 2000/60/EC. This directive is important for a good qualitative and quantitative state of all open water bodies in Europe (European Commission, 2016). A good quality of water bodies is obtained by: the protection of unique and valuable habitats; protection of drinking water resources; and, the protection of bathing water. This is regulated by looking at the chemical values of water bodies and the ecological functions in local ecosystems. Although much progress is made in the quality of water bodies in Europe, future improvement needs to be made by involving citizens and by even further cleaning bodies of water (European Commission, 2016).

On a national level many laws and regulations apply. Important for the research cases in the peatlands are regulations concerning the use of fertilizers and the protection of soil types (in Dutch: *“Meststoffenwet”*, *“het Besluit Gebruik Meststoffen”* and the *“Wet Bodembescherming”*) (Roelsma, Kselik, & de Vos, 2008). The use of fertilizers is both important for farmers to sustain their business and for ecological value of an area thus to prevent eutrophication of the environment because of mainly the use of fertilizers (Kenniscentrum InfoMil, 2018a; Geurts, et al., 2009). The law for the protection of soils (in Dutch: *“Bodembescherming”*) was designed to regulate and enforce soil types in the Netherlands. Groundwater is an important part in this law as it is a crucial element in any soil type (Dutch Government, 2017). Nature protection is also regulated on a national level (Woestenburg, 2009).

Provinces and water boards have different kinds of powers, laws and regulations that are applicable for the areas within a certain jurisdiction. Provinces and water boards are responsible for the water ordinances under their control as mentioned previously. In the research case of Midden-Holland the provincial law (in Dutch:) *“Waterverordening Zuid-*

Holland regulates: water safety, water quality for agriculture and nature and zoning policies for land use (Province of Zuid-Holland, 2016). For peatlands in the selected cases the laws and regulations on these legislative levels are most important as they focus on the rights for farmers to farm and use water for their lands.

5. Characteristics of the farmers

This chapter looks at the characteristics of farmers in accordance with the themes derived from the conceptual model. Paragraph 5.1 looks at the willingness of farmers and in paragraph 5.2 the actual possibilities of farmers to adapt to new technologies is discussed.

The stereotype of farmers to be stubborn and low-educated are outdated. As nowadays more farmers are having academic degrees and more farmers are broadening their business models. According to Walter Kooy, official in water board De Stichtse Rijnlanden there are two views to see the possibilities for farmers in the future. The pessimistic one in which water boards help farmers during the next century to slowly but surely aid them in their dying business. Or an optimistic view in which farmers adapt their business model to higher (ground) water levels and broaden their business model by providing additional services like a bed-and-breakfast, campground etc. (Kooy, personal communication, 2018). For this research it was helpful to look at the willingness and the possibilities of farmers to use new technologies and innovations.

5.1 Willingness to use new technologies

In order to understand the willingness of farmers one must take a look at the social aspect of a farmer's situation. In most cases motivation of farmers to invest or adopt new technologies depends on their social structures. Many farmers operate in family businesses and therefore attach high values to family situations. The influences of neighboring farms and farmers are also important for understanding the possibilities of farmers to implement new technologies (van Doorn, et al., 2017). The influence of a farmer's community should not be underestimated as farmers identify themselves with other people in the business. Key figures in the business are seen as leaders in the business. Meaning that if a key figure adapts a new measure will persuade smaller farmers to adapt this measure as well, if this measure proves to be beneficial (Kooy, personal communication, 2018; van Doorn, et al., 2017). Even though the influence of colleague-farmers is substantial are farmers also caring for the opinions of the public. Public appreciation for sustainable agriculture works motivational for a farmer's business (Burton & Schwarz, 2013). Public image might therefore help to persuade farmers to change their business model into a more sustainable one (van den Born, et al., 2016).

Because of a farmer's tendency to access new technologies based on opinions and views of other farmers in the area a collective approach should be taken if one likes to promote new technologies. Dutch agriculture is organized pretty well, for example in: cooperatives, sector collectives for produce and nature associations (van Doorn, et al., 2017). Steering behavior via these organizations is more successful than to approach individual farmers. Behavioral change by farmers is best achieved through the help of a collective of farmers (van Doorn, et al., 2017). For the case of innovation in peatlands collectives are a starting point for implementing new technologies. KTC Zegveld is an example of an organization that shares knowledge between farmers, companies, legislators and waterboards (Jansen, Personal Communication, 2018). Another important player is LTO Midden Zuid-Holland. This organization represented interests of farmers in agricultural areas. The composition of the board of LTO reflects the members of the organization (LTO Noord, 2018). LTO can be a powerful partner in the exchange of interests, knowledge, bottlenecks and opportunities for new technologies in peatlands (Jansen, Personal Communication, 2018; van Doorn, et al., 2017).

Enthusiasm under farmers about new technologies and innovations are noticeable by the Peatland Innovation Center. Erik Jansen explained that farmers are very eager about working with systems that regulate groundwater levels. Especially the pressure drainage system in which farmers themselves have the control over the groundwater levels under their fields (Jansen, Personal Communication, 2018). New researched technologies at the Peatland Innovation Center proved

5.2 Possibility to use new technologies

Farmers possibilities to use new actual technologies and innovations also dependent on laws and regulations. To stimulate farmers but also, the farmer's land and regulated water levels need to be in accordance with new technologies. A long-term solution for the next century is not yet feasible as on short-term current agricultural practices can be maintained. And for agriculture there is less urgency to change behavior than for build-up areas as these areas will struggle with more financial troubles with subsiding ground levels.

Looking at climate-smart agricultural measures, farmers are most concerned about changes in their business. As many climate-smart agricultural changes require more attention and work for maintenance and management (Melman, et al., 2011). As financial costs are an important part in most farmers' business models. Farmers in peatland areas need financial support to improve on climate-smart agriculture. Many farmers refrain from investing as the (small) financial gains are in their opinion generally not worth investing (Bos, Gies, & van Male, 2017). Improving the cost-effectiveness of technologies can improve this situation.

On government level financial incentives can support climate-smart technologies. The government can use financial instruments to stimulate certain behaviors. The government can do this in two ways, by either taxing or spending money through grants (Kooy, Personal Communication, 2018). Government grants are an important tool to stimulate behavior change into more environmental friendly business management. This is because farmers outweigh the benefits of a grant to the costs and time they spent otherwise. Financial rewards for farmers is the most effective strategy for reaching short term goals in climate-smart agriculture (van Doorn, et al., 2017).

5.3 Conclusions

To analyze the characteristics of the farmer this research looked at the willingness and the possibilities of farmers to use new technologies and innovations. In general enthusiasm under farmers about new technologies and innovations is noticeable. Nonetheless are farmers heavily influenced by their social constraints like family and colleague farmers. To overcome this threshold of social constrictions legislators can influence farmers behavior with financial instruments.

6. Characteristics of the climate-smart agricultural measures

6.1 Climate-Smart Agriculture

As mentioned in the introduction and earlier paragraphs is agriculture subjected to a change in the environment due to anthropic and climatic changes. As of today, climate change is already hindering agricultural yields of their full potential. Worldwide reduction in the yields in maize and wheat are already linked to the effects of climate change, researchers warn for even more reduction of crop yields if global temperatures keep rising (Lobell, Schlenker, & Costa-Roberts, 2011). Realizing global food security is a needed to reduce the effects of climate change on crop yields. A prime obstacle for this global food security is the global increasing human population. The worldwide rapidly increasing human population will pressure the availability of finite agricultural commodities, as demand for food increases. The

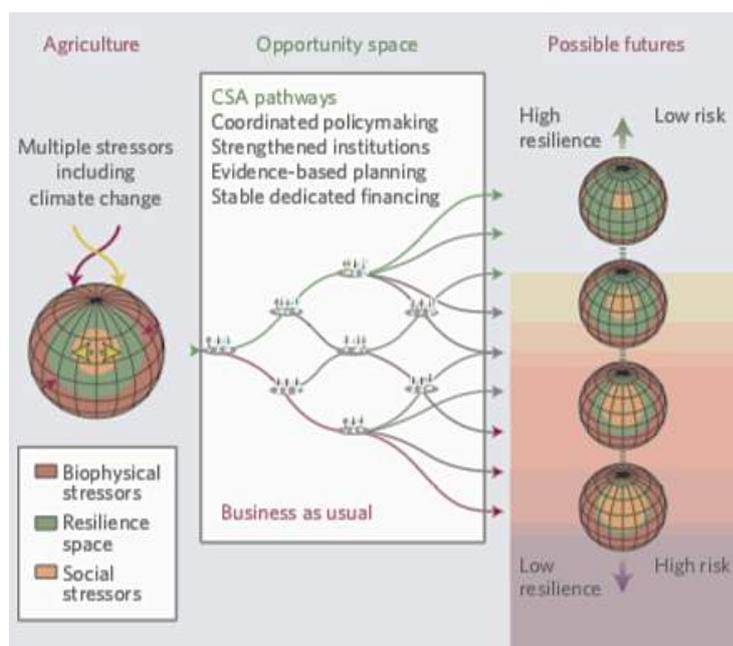


Figure 9: Climate-resilient transformation pathways for agriculture (Lipper, et al., 2014)

development of a sustainable agricultural system is needed if the demands of future populations is to be met (Pimentel, 2009). Figure 9 shows several pathways to potential outcome scenarios for agriculture in the future. Where the “*business as usual*” scenario results in low resilience and high risk for food security (Lipper, et al., 2014). Meaning that when agriculture in peatlands continued with current practices, yields will drop and the resilience to higher water levels and subsidence will be low. Whereas a pathway in which climate change is integrated and implemented in the sustainable agricultural strategies, the resilience will be high and risks for food security will be low (Lipper, et al., 2014). In between these outliers’ multiple pathways are possible for future scenarios.

An approach for farmers to transform their agricultural system in coherence of the effects of climate change is called ‘*Climate-Smart Agriculture*’, or CSA. CSA is resilient to stressors in climate changes thereby reducing the risk of yield losses and damages to crops. The overall aim of CSA is to use agricultural systems to achieve global food security. Where adaptations and mitigations to current biophysical and social stressors are implemented (Lipper, et al., 2014; Campbell, et al., 2016). To effectively achieve these the objectives for CSA urgent coordinated action from public, private and civil on the local, national and international level is required (Lipper, et al., 2014; Dwivedi, et al, 2017). This urgent action should focus on increasing financing and their effectiveness in CSA and to develop sound policies for agricultural lands (Lipper, et al., 2014). Social stressors include. National public, private and civil society stakeholders should reduce the costs of information access and they should enhance people’s access to assets (Lipper, et al., 2014). Also, in reducing information costs and barriers adaptive capacity through enhancing people’s access to assets, including information. To reduce the impact of social

stressors social inclusion through a focus on people who are most vulnerable to climate change should be implemented (Campbell, et al., 2016).

In the Netherlands the Wageningen University and Research published a statement to adapt climate-smart agriculture as mitigation process in climate change. In this 2011 statement five objectives were set-up to make way for climate-smart agriculture (WUR; Dutch Ministry of Economic Affairs; The World Bank; FAO, 2011). In short, these five objectives are:

1. *“Urge increased farm and landscape level research, education, extension and innovation in climate-smart agriculture;*
2. *Call on all stakeholders to contribute to platforms and capacity enhancement that improve dialogue and learning about proven policies, technologies and practices for climate-smart agriculture;*
3. *Call on implementing agencies from national governments and civil society, and the private sector, to provide the impetus for, and support to, proven climate-smart technologies and practices;*
4. *Urge all stakeholders to put in place the needed policies, strategies and frameworks to build climate-smart agriculture, and the associated research and development, and*
5. *Urge national governments, regional organizations and private sector to allocate adequate financing to climate-smart agriculture and rural development, and the associated research and development”.*

- WUR, Dutch Ministry of Economic Affairs, The World Bank and FAO (2011)

To define what climate-smart agricultural practices are applicable for Dutch peatlands, this thesis research used the objectives used in the works of the WUR, Dutch Ministry of Economic Affairs, The World Bank and FAO (2011); and the works in the paper of Lipper, et al. (2014). The conclusion of this chapter will clarify on the definition of smart climate agriculture for Dutch peatlands. Key in climate-smart agriculture is the maximum sustainable yield. This yield defines what yield can be achieved by making sure a continual use of the commodity is guaranteed (Wright & Boorse, 2014).

6.2 Future land use of peatlands

There are several scenarios for peatlands in the future. This paragraph looks at a series of developments in management and innovations that can improve agricultural practices in Dutch peatlands.

6.2.1 Water management in peatlands

In the past water boards in peatlands managed water levels based on farmers preferences. This resulted in a continued lowering of water levels as the peatland subsided. Even though new technologies make it possible to continue to lower the water level to maintain current agricultural practices. However, this is a not a desired situation as the land and water level will even further subside increasing the risk of flooding. Therefore the current strategy of water boards is to maintain a certain water level and to help farmers to maintain their agricultural practices for as long as possible (Kooy, personal communication, 2018). Water boards help farmers by providing knowledge and organizing the transition processes to other agricultural practices. Because water boards now do not lower the water levels, it is important for farmers to keep track of their subsidence, so they are able to practice their form of agriculture for as long as possible. Farmers however themselves need to invest in their business.

6.2.2 Wet crops

Wet crops are crops that are grown with water levels above ground level. Rice is an example of a crop that can be grown under these conditions (van Gerwen, Bijman, van de Riet, & Hogeweg, 2017). For Dutch peatlands wet crops can be an alternative to current agricultural practices as this slows the rate of land subsidence substantially (Boersma, 2015). Current developments into wet crops under Dutch climatic conditions, are still being researched and Eric Jansen (Personal communication, 2018) estimates it can take up to 20 years for viable results to be implemented in actual agricultural practices. Typha species and aquatic ferns, are two of species that are currently being researched as viable agricultural alternatives. These plant species can be used as feed for cattle, so that less food has to be imported from distant countries like Brazil, or can be produced as insulation material (van Gerwen, Bijman, van de Riet, & Hogeweg, 2017). Part of this research is the investigation and development of a workable market to sell these crops.

Advice of the Peatland Innovation Center was to not take wet crops in account as a viable measure for climate-smart agriculture. Therefor this research will not continue researching wet crops as a climate-smart measure.

Reed however is currently one of the most developed wet crops on the market. The reed plant will next be discussed as an example since it is for the Dutch situation the most viable wet crop (Korevaar & van der Werf, 2014). Note that reed is to demonstrate the viability of wet crops only, since there was decided not to continue looking into wet crops.

Reed

Reed ("*Phragmites australis*") is a species of grass that grows in fresh or brackish conditions. The plant grows under all sorts of fertile and non-fertile conditions, such as: swamps, wet grasslands and at the edges of agricultural fields. The fast-growing rate of reed make that the yield of biomass is high compared to similar crops (Korevaar & van der Werf, 2014).

Benefits

Ecosystem services are among the most important benefits of reed. Reed is able to purify water, as it absorbs phosphorous and nitrogen dioxide, and it releases valuable nutrition to the water. Reed also aids in slowing the rate of land subsidence as it contains its mass even in wet conditions, on long term the buildup of layers of reed might eventually lead to rising surface levels. Moreover, reed's high biomass yields are attractive for several industries (Korevaar & van der Werf, 2014).

Disadvantages

Reed is not a valuable commodity on the market as its value is too low to maintain a viable business. This is why reed as crop is not preferred by farmers as a financial business model (Korevaar & van der Werf, 2014). Nonetheless, if we were to include a price for the ecological benefits reed offers natural systems, such as water treatment and slowing the rate of subsidence a more feasible business model will be the result. Taking these ecosystem services in account can slow the rate of subsidence of peatland areas and will make reed a viable agricultural commodity (Hendriks K. , 2018).

6.2.3 Returning to a natural state

Originally Dutch peatlands had a dense and species rich flora and fauna. The ecological wealth of these areas was removed already centuries ago. The former abundance of reed marshes, small alder woodlands, and fen pools were abundant with aquatic, terrestrial and flora

species (Verhoeven & Setter, 2010). With the drainage of areas and the fertilization for agricultural fields, species richness has declined. Returning the peatlands to their original state will slowly bring back the rich biodiversity which was once in the area (Verhoeven & Setter, 2010). However, returning to this natural state is not desirable since many economic businesses need to be closed and the area cannot be used for the production of agricultural commodities (Kooy, personal communication, 2018). Therefore this research will not further take in account returning peatlands to their original state.

6.2.4 Underwater drainage systems

Underwater drainage systems (in Dutch: onderwaterdrainage) is a system of semi-open tubes that connect two bodies of water. This result of these drainage system is that the water level in both the summer and winter situation are more neutral because water is more rapidly exchanged between bodies of water. This results in having relatively more dry soil during the seasons, which improves the carrying capacity of the soil, thereby securing the fields conditions for farmer and grazing cows (Hendriks, van den Akker, & Heijkers, 2018). A negative effect of the underwater drainage system is the demand for fresh water. Especially during dry seasons, the demand for water will increase as the water table in fields are equalized this causes a competition in water demand with other functions that require fresh water (Kwakernaak, 2015; Kuijpers, 2014)

These drains are places 10 to 20 centimeters below the surface level of a selected water body. The locations of drains help to drain land more evenly in wet conditions by transporting water to the nearest water bodies. This prevents the formation of water bubbles which keep the ground wet under normal circumstances. Under dry conditions open water can flow in these drains towards the field improving the water table under the fields. This helps to keep the peaty soils in wet conditions reducing oxidation of peat, as the water table in the field is levelled with the water table in of the nearest water body. Figure 10, on the next page, shows a schematic overview of a summer and winter situation with the installment of an underwater drainage system. In this figure it is clear to see that the drainage system helps to drain water easier from and into the field (Deru, et al., 2014).

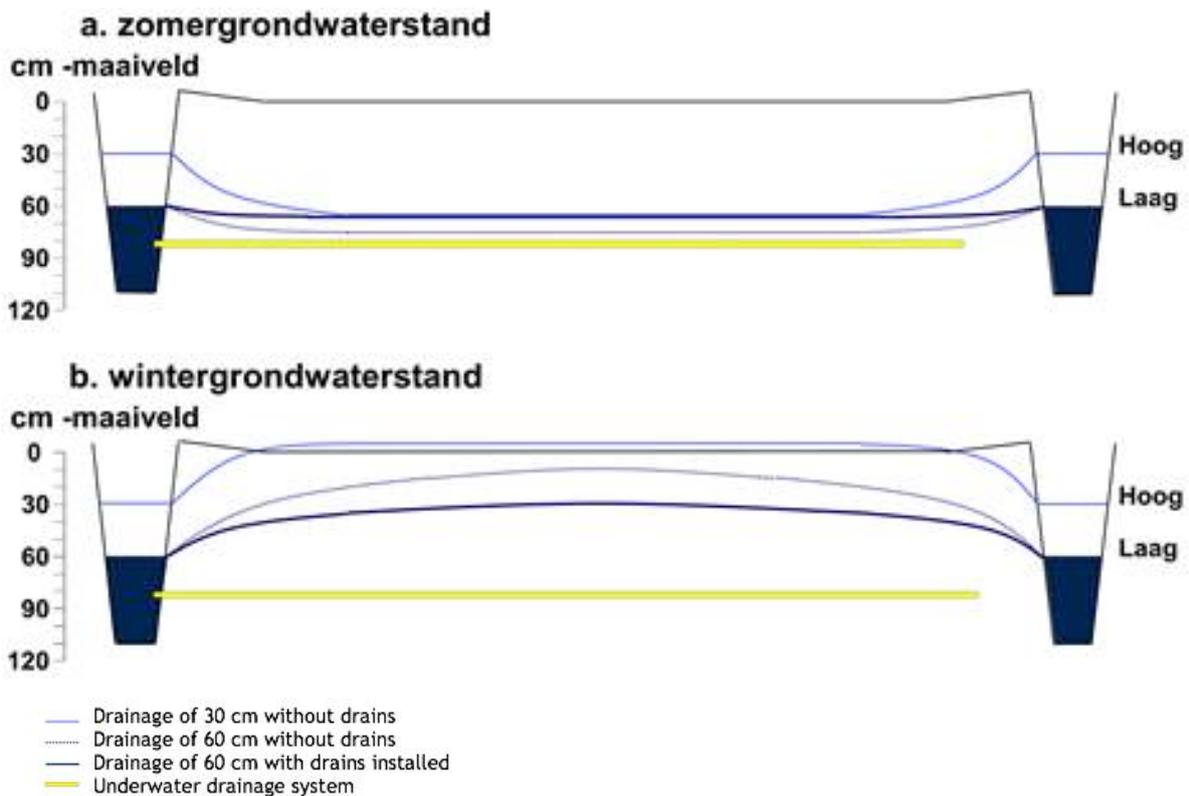


Figure 10: Schematic overview of an underwater drainage system, which shows 30 and 60 centimeters drainage in relation to the ground level. A). *Summer situation*, in this dry situation without drains, we see that in both the 30 and 60 cm water drainage results in a parabola water-curve between two bodies of water. By installing the drainage system this curve is flattened out B). *Winter situation*, in the winter situation the water curves upward as a result of wet conditions. Because the drainage in the middle of the fields is low swampy conditions occur making agriculture impossible. The drainage system drains this excess water more quickly resulting in a drier situation which is beneficial for the farmer (Hendriks, van den Akker, & Heijkers, 2018).

For the farmer the drains have a series of positive effects. First, cows are able to stay outside for longer periods of time during the year. Normally cows have to go inside if the ground shows signs of wet conditions. This is because too wet conditions can result in foot rot by cows as bacteria in the soils enter weakened tissue (Gould, 2014). Secondly, the growing season for crops, but mostly grass, is prolonged, thereby increasing revenues for farmers (Jansen, Personal Communication, 2018). Thirdly, the rate of land subsidence is significantly slowed by keeping more sections of peat wet during the year.

The costs of the system are somewhere between €1.700 and €2.500 per ha of land, depending on the distance between two bodies of water (Hendriks, van den Akker, & Heijkers, 2018; Melman, et al., 2011). At this moment the system itself is not yet profitable, but the benefits for the farmer make underwater drainage a cost-effective system (Jansen, Personal Communication, 2018).

Effects on the natural environment

The installments of underwater drainage systems do not cause serious changes in the biodiversity of peatlands. But, a dryer top layer of soil caused by the underwater drainage system improved habitat conditions for earthworms. As earthworms have more depth to live as the water level is reduced. By having more earthworms, the structure of the soil increased, making it more fertile (Deru, et al., 2014). Even though the fertility of the soil is improved, the effects of earthworms living deeper into the soil might affect food security for bird species.

Moreover, a drier soil increases the resistance bird's beaks receives searching for food in the top layer of soils. The actual effects of this are not yet fully studied in relation with underwater drainage systems (Deru, et al., 2014; Melman, et al., 2011).

Effects on land subsidence

As mentioned is the slowed oxidation process of peat, as a result of a higher water table, beneficial for the rate in which land subsides. The rate in which land is subsiding is heavily depended on local conditions of an area. But in general half till 1/5th the rate of subsidence is achieved with the installment of underwater drainage systems (Jansen, Querner, & van den Akker, 2009; Hendriks, van den Akker, & Heijkers, 2018; van den Born, et al., 2016). The tackled effects of subsidence have no negative effects on agricultural yields, as mentioned they cause positive farming conditions year-round for farmers.

Effects on greenhouse gas emissions

A positive effect of a lower rate of land subsidence in peatlands is a reduction in the emissions of CO₂. Around two percent of national Dutch CO₂ emissions derive from farms in peatlands. If underwater drainage systems were to be implemented in most of the Dutch peatlands, over a quarter of CO₂ emissions can be avoided (van den Born, et al., 2016).

In less quantities the greenhouse gasses methane (CH₄) and nitrous oxide (N₂O) are also emitted from peat soils. Most of these gasses are released by a lowering of the water table (Hendriks, van den Akker, & Heijkers, 2018). Both emissions of methane and nitrous oxide are heavily depended on natural conditions of the soil. Methane but mainly nitrous oxide are considered to be strong greenhouse gasses but are not released in quantities compared to CO₂, yet their effects might be stronger. Nitrous oxide is a naturally occurring result of soil nitrification and denitrification processes in the soil. The use of fertilizers and the grazing of cattle increases nitrogen levels in the soils which contribute to nitrification process in the soil. Researchers from the Wageningen University concluded that dry soil conditions resulted in more nitrous oxide emissions compared to wet soil conditions (Pleijter, van Beek, & Kuikman, 2011). Thus, CO₂ emissions are decreasing when using underwater drainage systems, but nitrous oxide emissions will increase as a result of dryer soil conditions year-round. It is important to monitor and prevent the emission of greenhouse gasses in according with regulations and environment-goals set by the Dutch Government (Dutch Government, 2018).

6.2.5 Pressure drainage

Another measure that is being researched for peatlands is pressure drainage (in Dutch: drukdrainage). In this system the water levels in water bodies and in groundwater are separated trough water regulations in an artificial well. An artificial well is installed on the field which regulates the flow of water from water bodies and transports these troughs a system of pipelines under a field. A pump in the well is able to pump water to and from the well to the either groundwater of open water bodies. Pressure from the well can make water flow into the underground pipelines a pump can subtract water from the field and into open bodies of water. This system is able to regulate water levels on a single stretch of land. The only condition is that sufficient water is needed in open bodies of water for the system to operate completely (Bos, Gies, & van Male, 2017). Figure 11 shows a pressure drainage well in Zegveld, the Netherlands. A mayor advantage of this systems is similar to that of underwater drains, as the lowering of groundwater levels enables the farmer to use his land

for longer periods during the year (Bos, Gies, & van Male, 2017; Hendriks, van den Akker, & Heijkers, 2018).

Pressure drainage systems offer almost the same benefits and cause similar effects for biodiversity, land subsidence and greenhouse gas emissions compared to underwater drainage systems (Bos, Gies, & van Male, 2017; van Gerwen, Bijman, van de Riet, & Hogeweg, 2017).



Figure 11: A test location for a pressure drainage system. A well is installed near an open body of water to regulate the groundwater level under a field through a series of pipelines (Own Work, 2018).

A positive feature of this system is that the farmer is able to regulate water levels on his own by operating the pump in the well. If the technology is further innovated this technology can eventually be simplified and operated through an app on smartphone devices (Jansen, Personal Communication, 2018). For farmers to be able to operate and regulate their own (ground)water levels, requires awareness and information for the farmers on how to operate and handle the drainage system (Jansen, Personal Communication, 2018).

A negative aspect of this system is that the technical aspects of the system need to be further innovated. More innovation and experiences with the system will improve the accessibility of the drainage system. Also, research is needed into the suitability of the system in the farmers business case, as well as the financial profitability of the system (van Gerwen, Bijman, van de Riet, & Hogeweg, 2017; Jansen, Personal Communication, 2018).

6.3 Conclusion

Climate-smart agriculture is a form of agriculture in which sustainable principles are applied. CSA is resilient to stressors in climate changes thereby reducing the risk of yield losses and damages to crops. These principles involve food-security and ensuring that needs of future generations are also met.

Future land uses and climate-smart measures for peatlands include: wet crops, returning to a natural state, underwater drainage systems and pressure drainage systems. on advice of the Peatland Innovation Center this research will not take wet crops in account as a viable measure for climate-smart agriculture. Returning to a natural state is not desirable food

security for the increasing global population is not met by returning agricultural land to their natural condition.

Looking at current and future prospects, is the development of underwater drains the most promising climate-smart agricultural measure for peatlands. This is because underwater drains both improve climatic and farming conditions. Greenhouse gas emissions are namely haltered using the underwater drains. This system also improves the efficiency of land use for farmers as the productivity of their field is enriched by longer growing periods. Pressure drainage systems look to be a promising alternative to underwater drains in the future. But as of today, is the technology still being innovated and currently it not possible to up-scale the larger areas.

7. Interpreting the discourses

This research used the steps in discourse analysis in accordance with the steps defined by Florian Schneider (2013). In this chapter the interpretation and the presenting of the findings are discussed. Paragraphs 7.2 and 7.3 zoom in on the selected cases for more detail.

Interpreting collected data

This paragraph tries to interpret the discourses between the selected stakeholders in Dutch peatlands. In the table below the main arguments between actors are shown.

	Farmers	Legislators	Water boards
to Farmers	Dutch agriculture is organized pretty well, for example in: cooperatives, sector collectives for produce and nature associations. This shows the tendency of farmers to look at the way other farmers organize and execute their business. The organization of farmers can aid in implementing new measures (van Doorn, et al., 2017)	Municipalities can benefit from collectives, such as: KTC Zegveld and LTO in the case of Midden-Holland. These collectives help strengthening the relations and understanding between legislators and farmers (van Doorn, et al., 2017).	Water boards goal is to help the farmers maintain their business as long as possible by not compromising on their core goals of providing water safety in their area (Kooy, Personal Communication, 2018).
to Legislators	The EU does not fund under water drainage systems as well as the national government. This prevents the switch to smart-climate agriculture (Bos, Gies, & van Male, 2017). Laws and regulations can support farmers in their ambitions to adapt climate-smart agricultural measures. Financial incentives can help farmers to fasten the transition process. (van Doorn, et al., 2017). As individual approach to farmers will not have the same effect as a collective of farmers it is important to approach the situation accordingly (van Doorn, et al., 2017). Walter Kooy was reluctant in linking the researcher to farmers in the field as they feel objects and materials for researches (Personal Communication, 2018).	x	Waterboards are responsible for the treatment of municipal wastewater (Kenniscentrum Infomil, 2018b).
to Water boards	Financial incentives here can help speed the process in which water adaptive measures, like underwater drainage systems that should be installed to slow the rate of land subsidence (Kooy, Personal Communication, 2018)	Legislators on municipal level are obliged to collect water in accordance to their sewer plans and to transfer this water to treatment plants of the water boards (Kenniscentrum Infomil, 2018b).	x

From this table we can conclude that the most tension are between legislators and farmers. It is namely here that the most interaction is present. As legislators shape the field in which farmers can maintain their business. This is because legislators present laws and regulations for farmers to operate their business. Researchers A.P. Bos, T.J.A Gies and B. van Male (2017) defined four recommendations of farmers towards legislators to improve the transition into climate-smart agriculture. These four recommendations are:

1. take a positive position in which the opportunities, experiences and knowledge of farmers is used;
2. strive to a situation in which both the legislators as farmers are benefitted, taking mainly in account the financial perspective of the farmer;
3. develop a clear vision for the future of peatlands, taking in account land subsidence, and process this in a "*plan of approach*"; and,
4. make government grants available to install climate-smart measures on farmlands, and to fund research into possible effect of these measures.

(Bos, Gies, & van Male, 2017)

When looking at climate-smart agriculture, the general conclusion is that farmers need to be financially or legally persuaded to continue into a more sustainable form of agriculture. Farmers agree on this financial stimulation, as mentioned above. Nonetheless, as discussed in paragraph 5.1, can farmers also be influenced by public opinion to transform their business more sustainably.

Another important factor for climate-smart agriculture is the public. The public in general is very concerned with sustainability issues. According to Walter Kooy (Personal Communication, 2018) the public is generally, individually, divided in two sets of thought. One is the consumer at home who is aware of environmental issues; and two a consumer in front of a shelf in the supermarket. This results in a public outspoken opinion but sometimes consumer behavior lacks the strength of the public opinion. Not for all cases this dichotomy is true. Consumer awareness is able to change consumption and thus production patterns, and thus cause more sustainable food production. Consumer awareness and their actual consumption behavior can ultimately change production patterns, as consumers can reward sustainable production or punish less sustainable alternatives (Wright & Boorse, 2014; Grunert, 2011). For the cases of Midden-Holland and Waterland is consumer behavior is not an applicable aspect as a broader public capacity is needed to change consumption patterns in favor for climate-smart agriculture. Moreover, important for farmers in peatlands is land subsidence, thus measures to reduce the rate of subsidence and improve farming conditions on fields is more appreciated.

8. Conclusions

This chapter combines the results of this research and gives an overview of the conclusions and recommendations. First the conclusions are shown in paragraph 8.1. These conclusions lead to the answering of the main research question in paragraph 8.2. Later paragraph 8.3 shows the recommendations.

8.1 General conclusion

The following conclusions and results have emerged from the research and are explained point by point in this paragraph:

- Farmers are in general willing to adopt new climate friendly measures, this in contrast to the general view of stubbornness of farmers.
- Farmers are socially constrained by family and colleague farmers in adopting climate-smart measures, to overcome this threshold of social constrictions legislators can influence farmers behavior with financial instruments.
- Wet crops are a potential alternative for farming in peatlands, but much research still needs to be conducted to make this a viable alternative.
- Returning peatlands to nature is not a desirable situation as food security in the future might not be achieved.
- Underwater drains are currently the best option for smart-climate agriculture in Dutch peatlands. This is because the measure improves food security by prolonging the grazing and growing period on drained farmlands. Moreover, groundwater levels with underwater drains keep a larger proportion of peat soil submerged in water, thereby reducing the emissions of greenhouse gasses substantially.
- Pressure drainage systems look to be a promising alternative to underwater drains in the future. But as of today, is the technology still being innovated and currently it not possible to up-scale this in larger areas.
- The public opinion can be a helpful aid for farmers to adapt new measures.
- To improve the transition of farmers into climate-smart agriculture financial grants from legislators are needed as well as a clear legislative vision on the future.

8.2 Answering the main research question

What are the main perspective frames of climate-smart agricultural practices intergraded with current Dutch groundwater management practices?

The main perspective frames in this research were divided into three stakeholders: legislators, water boards and farmers. Over-all, both the water boards and legislators are a single front and the most tensions is visible between these legislators and farmers. This is explained by the fact that legislators shape the field in which farmers can maintain their business. Water boards comply with national Dutch regulations and are responsible for the safekeeping of Dutch water levels and qualities. Current practices in peatlands correspond to not an automatic lowering of the water table in accordance with the rate of land subsidence. This practice will pressure agricultural businesses in the future as ground water levels rise. A climate-smart agricultural measure should therefore be able to adapt with a water level that is relatively higher than it used to be. An underwater drainage system is such a climate-smart measure that levels out the groundwater level in accordance to the water level in the nearest body of water. Because of this levelling, water peaks are flattened during the seasons,

improving farming conditions and slowing the rate of land subsidence. This system also contributes to less emission of greenhouse gasses as groundwater levels are more stable. At the moment the system itself is not yet profitable, but the benefits for the farmer make underwater drainage a cost-effective system. Farmers are happy to adopt this system as long as it is financially attractive, and laws and regulations could help to guide this situation.

8.3 Recommendations

This paragraph shows general recommendations for climate-smart agriculture on Dutch peatlands.

- Legislators should take a positive position towards farmers and should thereby use existing knowledge and opinions of farmers.
- A scenario where both the legislator water board and the farmer are satisfied is an ideal outcome scenario.
- Government grants for the realization of under water drainage systems can improve the profitability of a system and thereby making the system financially more interesting for farmers.
- Legislators should clearly define how they will legislate in the future, including the handling of the effects of climate change. New structured national plans are key in realizing this.
- More research needs to be conducted into the applicability and usability of wet crops. This can speed up the process of making this a viable alternative to the underwater drainage system.
- More or detailed research into the effects of the public on agriculture in peatlands can help to improve the understanding on the effect of public opinion about climate smart agriculture in peatlands.
- Understanding of the social constraints of a farmer can also help to find different ways to solutions in implementing climate smart agricultural measures for farmers.

9. Discussion

This research had its initial deadline set for Thursday the 28th of June 2018. Because of personal circumstances of the student the deadline had to be moved to the Friday the 17th of August. This thesis is supposed to give the reader insights in the current developments in climate-smart agriculture for Dutch peatlands. By conducting a desk research and interviews this research provided a well written conclusion and recommendation.

The starting point of this research was a selecting a theoretical framework. Social constructivism was selected as interpretive framework as it places the perspectives of different actors in a broader context. Discourse analysis was employed to uncover the relations between the actors in the field of agriculture in peatlands. This research used the steps of Florian Schneider (2013) to conduct this research, by conducting a discourse analysis into the involved stakeholders. The choice of water boards, legislators and farmers as stakeholders was an ideal strategy to understand the mutual discourses, as these are the most influential stakeholders in the research cases.

Underwater drainage systems proof to be the best measure for climate-smart agriculture in the near future of Dutch peatlands, as the distant future has too many climatic variables in play. The underwater drainage systems can improve the environmental situation by reducing greenhouse gas emissions as well as slowing the rate of subsidence in farmlands. Food security is achieved since farmers have longer growing seasons and the effects of wet and dry situations are levelled by the drainage system.

Noticeable in this research was the reluctance of stakeholders to connect me to farmers in the case areas. Walter Kooy for example was cautious in linking me as researcher to farmers in the field as they generally feel objects and materials of studies thereby not willing to cooperate with any (more) researches. This shows that there still is a tension between the stakeholders involved in peatland agriculture. This tension can perchance be lifted if more understanding between actors is present. However, a constant exchange of ideologies and ideas is not realistic. Therefor the use of the collectives, like KTC Zegveld and LTO-Noord, can aid in this process. An approach to more understanding with the use of these collectives needs to be further researched in the future.

As noticed by the reader this thesis research has a rather scarce number of interviews for a social study. Especially since the goal of this research was to understand the different stakeholder's perspectives, was a minimum of 5 interviews the original starting point. Setbacks were as previously mentioned personal circumstances, but also the availability of interviewees during the summer months of 2018. Nonetheless am I convinced that this thesis is still helpful in understanding the current state of climate-smart agriculture in the peatlands of the Netherlands. If I were to redo this research, I would spend more time and effort into meeting more actors and conducting more interviews; this to further improve the quality of the research. All in all, am I convinced I provided this thesis with a well applicable and suitable result to the main research question.

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Annex 1: Interview with Walter Kooy

Interview with Walter Kooy, official in general board of Hoogheemraadschap De Stichtse Rijnlanden. Referred to in texts as Kooy, Personal Communication, 2018.

Date: 19th of July 2018, 11:00-12:30h, Vossenlaan 7, Bosch en Duin.

This interview focused around Walter Kooy's perspective on the future of agriculture in the peatlands of western-Netherlands. The interview was conducted in Dutch and had the following discussion topics/questions (in Dutch):

Vragenlijst

- Wat is het huidige/toekomstige beleid van het waterschap met betrekking tot de waterstanden die belangrijk zijn voor landbouw in veengebieden
- Onderwaterdrains zouden een goede manier zijn om waterstanden te beheren in veengebieden, is dit een goede oplossing voor de toekomst?
- Hoe zie jij de toekomst van veengebieden in Nederland, rekening houdend met klimaatverandering, waterstanden, droogtes, etc?
- Welke (huidige) onderzoeken/pilots zijn belangrijk voor het waterschap met betrekking tot veengebieden?
- Ik lees dat landbouw in veengebieden zich ontwikkelt in grofweg 3 manieren: grootschalig, natuurlandbouw (boer doet deel natuurbeheer), en stadslandbouw of lokale landbouw (afzetmarkt is lokaal en boer draagt zorg voor groenblauwe diensten). Graag hoor ik van jou hoe jij hier tegen aankijkt en welk(e) scenario(s) het meest wenselijk zijn voor het waterschap?
- Wat zou de overheid/waterschap kunnen doen om gedragsverandering bij boeren te stimuleren?

Annex 2: Interview with Erik Jansen

Interview with Walter Kooy, Innovation Manager at the Peatland Innovation Center in Zegveld, the Netherlands. Referred to in texts as Jansen, Personal Communication, 2018.

Date: 15th of August 2018, 10:00-11:45h, Oude Meije 18, Zegveld.

This interview focused around Erik Jansen's perspective on the future of agriculture in the peatlands of western-Netherlands. The interview was conducted in Dutch and had the following questionnaire (in Dutch):

Introductie

- Wie ben ik en wat is mijn onderzoek?
- Wat is jouw functie binnen VIC, en hoe ben je daar terecht gekomen?
- Hoe is het VIC tot stand gekomen?

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- Hoe verwerkt het VIC klimaatadaptieve landbouw in Veengebieden, en welke vorm van landbouw is het meest levensvatbaar in de toekomst?
- Zijn er vormen van landbouw die bodemdaling beperken, en zijn deze vormen ook winstgevend voor de boer?
- Ik lees dat landbouw in veengebieden zich ontwikkelt in grofweg 3 manieren: grootschalig, natuurlandbouw (boer doet deel natuurbeheer), en stadslandbouw of lokale landbouw (afzetmarkt is lokaal en boer draagt zorg voor groenblauwe diensten). Graag hoor ik van jou hoe jij hier tegen aankijkt en welke scenario het meest wenselijk is in jouw opinie?
- Verder lees ik dat het VIC op een aantal trajecten onderzoek doet, welke is het meest succesvol en meest levensvatbaar voor de toekomst?
- Zijn boeren enthousiast over deze nieuwe methoden?
- Hoe is de samenwerking met de verschillende partners binnen het VIC tot stand gekomen? En waarom zijn vooral provincies en waterschappen betrokken bij dit partnerschap?

Toekomst

- Is er een gedragsverandering nodig bij overheidsinstanties?
- Hoe zie jij de toekomst van veengebieden in Nederland, rekening houdend met klimaatverandering, waterstanden, droogtes, etc?