Radboud University Nijmegen

Master's thesis

The Practice of Adoption

Promoting and constraining conditions for the adoption of the social practice of subirrigation in Stegeren

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Master's Thesis research for the Spatial Planning programme
Specialisation: Cities, Water and Climate Change

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Preface

Hereby I proudly present to you my master thesis research on *promoting and constraining conditions for the adoption of the social practice of subirrigation in Stegeren.* By completing this research, I hope to finish my master of Spatial planning with a specialisation in Cities, Water and Climate Change at the Radboud University.

I experienced the process of writing this master thesis as intensive and challenging. However, the writing of this research was also interesting and enjoyable since I had meetings and discussions with different interesting new people in an informal setting. Moreover, I experienced the fieldwork phase of this research, in particular, as a very interesting part. The meetings I had with the different farmers and the water level manager adjusted my view on how to perceive the problems we are experiencing now due to climate change.

During the writing of this thesis, I retrieved lots of help and support from different persons for which I want to thank them. To begin with, I would like to thank my supervisor Dr. Sander Meijerink for his always helpful support and all the critical feedback he gave me. Secondly, I want to thank Onno Giller, who helped me integrate into the KLIMAP project, going to the interviews with me and the constant feedback during the writing process. In the third place, I want to thank my thesis lab group for the different fruitful and useful discussions we had during the writing process of my thesis. Further, I want to thank the respondents for the conversations and observations I had with them which thereby gave me the opportunity to finish this master's research. At last, I want to thank my family and girlfriend for their unrelenting support and the motivating talks we had which helped me finish this master thesis research.

This master thesis research is dedicated to my beloved grandpa Grad Goossens who unfortunately never saw the ending of this adventure.

Then there is nothing left to say, I hope that you will enjoy reading this master thesis research.

Teun Maurix

Nijmegen, 12-07-2022

Summary

Droughts are becoming an increasingly occurring phenomenon during the past years in The Netherlands. To tackle the consequences of this phenomenon, innovations in planning are necessary to adapt to these consequences. One way to test innovations in practice is in the form of pilot studies. One example where innovations are tested in practice in the form of pilot studies is the KLIMAP project. In the KLIMAP project, physical insights are developed on how the water and soil system on sandy soils could be established in a climate-adaptive way.
This research focused on one of the pilot studies of the KLIMAP project: the pilot study in Stegeren concerning the subirrigation system.
However, a general problem occurs with these pilot studies and thus also with the pilot study that was investigated in this research.
Namely, pilot studies are facing challenges on how these pilot studies can upscale to a broader extent. One way of increasing the upscaling of innovations is the adoption of these same innovations into practices; this results in a change of the old practices into new practices. Adoption is the decision of an individual to (not) implement innovations within the system of the individual. Nonetheless, not much information is in place related to this decision of whether to (not) adopt innovations.
To gain more knowledge about these adoption issues, the social practice approach together with the social practice theory was used in this research.
By using the social practice theory, it was possible in this research to gain information on the promoting and constraining conditions related to the adoption of the practice of subirrigation in Stegeren. These promoting and constraining conditions of the social practice of subirrigation were divided according to the three elements of the social practice theory. In this research, the focus was on the farmers' perspective regarding the promoting and constraining conditions for the adoption of this social practice.
After exposing the promoting and constraining conditions related to the adoption of this social practice, this research also investigated how this knowledge about these conditions could be used to develop a scaling strategy for the social practice of subirrigation.
During this qualitative research, semi-structured interviews and observations were used to collect data about these conditions. These semi-structured interviews and observations were conducted with the five farmers from the pilot study in Stegeren, four other farmers in or just outside the area of Stegeren and the water level manager of the Waterboard Vechtstromen. By including the water level manager and both groups of farmers who are part of the pilot study and those who are not, a diverse group of respondents was used in this research.

The results of this research showed that plenty of promoting and constraining conditions are present regarding the adoption of the social practice of subirrigation. Some conditions turned out to be crucial that can constrain or promote further adoption. For example, the soil type and condition together with the availability of water is crucial for the proper functioning of the subirrigation system.

Moreover, the lack of a clear cost-benefit analysis together with the uncertainty of yield of the subirrigation system hinders various farmers from further adopting the subirrigation system.

Nevertheless, the subirrigation system itself turned out to be simple to use and no new knowledge or skills had to be obtained to use the system. This resulted in an easy-to-operate and independent use of this subirrigation system by the farmers. However, this independent use of the system can be altered when technical errors occur, which cannot always be fixed by the farmers themselves.

At last, this research showed that farmers have a high valuation of this pilot study. Farmers are receiving overall good assistance from KLIMAP, however, most farmers stressed the fact that not the maximum effort is put into the project from the side of KLIMAP. Therefore, farmers are afraid that not the maximum results will be obtained and that the pilot study will fizzle out in the future.

All the obtained knowledge about the promoting and constraining conditions for each of the three elements of the social practice of subirrigation contributed to the development of a scaling strategy of this same social practice since this research revealed what promotes and constrains further adoption of subirrigation. This research made it clear what conditions have to be taken into account to make the scaling of this social practice possible.

Keywords: Adoption, Climate adaptation, Diffusion, Innovations, Scaling, Social practice theory, Subirrigation

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1. Introduction to research

1.1 Context and problem statement

Droughts have become an increasingly occurring phenomenon in Europe and The Netherlands during the past years. In The Netherlands, these droughts led to several consequences. These consequences vary from water shortages to economical consequences, such as agricultural sector export losses of an estimated 30% (Siepman, n.d.) (Ciais et al., 2005).
Because these droughts are not merely a 'rare' phenomenon, the national government, regional and local authorities have to invest more to become adaptive to droughts soon. Already some initiatives have started, for example, the water authority Vechtstromen is filling their ditches to delay the water drainage and the water authority Delfland started with an increased inspection of their dikes (Siepman, n.d.). However, more initiatives are necessary to become adaptive to droughts in the future. These (small-scale) initiatives can eventually be implemented on a larger scale to increase the adaptiveness to drought to a larger extent. Most of the time these initiatives adopt the form of a pilot study. A pilot study "refers to a mini version of a full-scale study. [...] Pilot studies are a crucial element of a good study design which can provide valuable insights for other researchers" (Van Teijlingen & Hundley, 2002).
Thus, one way to see if innovations in practice would work to tackle droughts is the use of these pilot studies. These pilots are most of the time, a collaborative initiative between different public and private parties, such as a water authority and a consultancy bureau.
One example of an applied research project in which pilot studies are conducted in the Netherlands is the project KLIMAP ('Klimaatadaptatie in de Praktijk', translated as Climate Adaptation in Practice). In the KLIMAP project, different parties collaborate, varying from public and private spheres. Together they conduct research, by using pilot studies, to develop physical insights on how the water and soil system on sandy soils could be established in a climate-adaptive way (KLIMAP, z.d.). Sustainability is one of the prime goals of KLIMAP, it is the focus of the various pilot studies conducted in KLIMAP.
Further, these pilot studies in the KLIMAP project are being conducted to research if these pilots achieve the desired result. And further how these pilots can upscale using functional tools and instruments to do so.
Nonetheless, a gap can be noticed in how to bring these pilot studies to a larger scale. Different scholars address the important role a specific complex environment has when focusing on scaling processes. "Scaling up and out is not simply a matter of scanning for and implementing known best practices. Political and institutional considerations continue to matter" (Hess, 1999; Matisoff, 2008; Smith, 2004 in Hughes et al., 2018, p.279).
Moreover, "actual methods of scaling are rather empirical and based on the premise of finding out what works in one place and do more of the same, in another place.[...]

As a consequence, scaling initiatives often do not produce the desired effect" (Wigboldus et al., 2016, p.45).
Thus, scaling pilot studies is not easily done because features of specific places are also of importance. Besides institutional or political features, the community is also involved in the practice of upscaling pilots.
To make upscaling of pilots possible among communities, it is important to investigate why a specific community wants to adopt innovations. Diffusing and adoption of particular innovations by the community are vital to make upscaling of these innovations, developed in pilot studies, possible.
This diffusion of innovations can be described as "the longitudinal spreading of (new) ideas, structures, and practices in social systems" (Breaugh et al., 2021, p.4). In this research, a community can be seen as a social system. The result of diffusion is the adoption of these new ideas or practices (Kaminski, 2011). According to Ameda et al., (2014, p.5), scaling can be seen as "a development pathway designed to make use of tested and validated practices and innovations in a way that can reach a larger number of people and cover wider geographical areas". Diffusion and adoption can help to reach this goal of scaling which is also mentioned by Breaugh et al., (2021).
How innovations and thus new practices diffuse and subsequently how present practices are adopted into new practices, as a form of innovation, is described in the Diffusion of Innovation Theory (DOI) (Rogers, 2003).

To relate this with the pilot studies in the project KLIMAP, in one of the pilot studies, the pilot study of Stegeren, five farmers are involved. The pilot study of Stegeren investigates if an adjustable drainage system with subirrigation, and surface water as a source, can improve the moisture availability of the crop by increasing the groundwater level. Those five farmers changed their way of irrigation to the way described in this pilot study and therefore contributed to the pilot study by changing their normal way of irrigation. Changing their normal way of doing, can be seen as an adoption of the new social practice of subirrigation. The result of the adoption is that these farmers are carrying out the pilot into a newly adopted social practice.

1.2 Research aim and -questions

This research aims to develop a scaling strategy for the social practice of subirrigation in Stegeren. To be able to find this scaling strategy, research will be conducted on what the promoting or constraining conditions of the farmers are for changing the social practice of sprinkler irrigation into subirrigation in Stegeren. These conditions are classified according to the three elements of social practice as described by Shove et al. (2012). Social practice in general consists of three elements: material, meaning, and competence (Shove et al., 2012). These three interdependent elements are vital because it represents what a social practice is based on and why a social practice could change. Therefore, in this research, it is crucial to investigate why these farmers were willing to adopt the social practice of subirrigation and further research if these conditions, for adopting this social practice, can help to understand if other farmers

are also willing to adopt the social practice of subirrigation. Finally, this research also focuses on the constraining conditions related to these three elements that could prevent the adoption of this social practice in Stegeren in the future.

To investigate what these promoting and constraining conditions are, semi-structured interviews with the five farmers will be conducted. Further, semi-structured interviews will be conducted with other farmers in Stegeren who did not change their way of irrigation and thus were not included in the pilot in the first place. This is to further improve the knowledge about the promoting and constraining conditions related to the adoption of the social practice of subirrigation that is being conducted in Stegeren. To gain as much contextual knowledge as possible, observations will also be used as a qualitative method to understand the social interactions of the farmers related to the social practice of (sub)irrigation. At last, secondary data analysis, such as previous reports from the Lumbricus and KLIMAP project on the pilot study in Stegeren, will be looked into. This research will be conducted by using the following main question and sub-questions.

Main question:
Which conditions promote and what conditions constrain the adoption of the social practice of subirrigation by the farmers' community in Stegeren and how can this knowledge be used to develop a scaling strategy for this social practice?

The main question can be divided into four sub-questions. The first three sub-questions are more social practice-related questions. The last sub-question refers to the relation between the knowledge about the promoting and constraining conditions and the development of a scaling strategy for this social practice.

1. Which conditions related to the 'material' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?
This sub-question focuses on deducing the conditions regarding the material element of the social practice of subirrigation. What the material element entails will result from the literature used in this research. In the semi-structured interviews and during the field research, questions will be asked and observations will be done to unfold these conditions. To eventually come to an integrative way in which particular conditions, regarding the material element, promote or constrain the adoption of the social practice of subirrigation.

2. Which conditions related to the 'meaning' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?
This sub-question works towards untangling the conditions related to the meaning element of the social practice of subirrigation.

The definition of the element meaning will be distilled by using the literature on the social practice theory. To untangle these conditions, semi-structured interviews and field research will be used again to do so.

3. Which conditions related to the 'competence' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?
This sub-question is centred around the investigation of the conditions regarding the element of competence of the social practice of subirrigation in Stegeren. Shove et al., (2012) will be used to describe the definition of competence and what this element entails. After the literature study, semi-structured interviews and field research will be used to sort out the promoting and constraining conditions for adopting the social practice that is being piloted in Stegeren.

4. How do the promoting and constraining conditions, related to the social practice of subirrigation in Stegeren, contribute to developing a scaling strategy for this social practice?
This last sub-question wants to answer the question of how a scaling strategy for this social practice needs to be developed by using the obtained promoting and constraining conditions related to this social practice.

1.3 Scientific relevance

This research investigates which conditions promote and what conditions constrain the adoption of the new social practice of subirrigation conducted in Stegeren. The use of a social-practice-based approach is not new to understanding why innovations will not move beyond the specialized segment where the innovation itself started. The use of a social-practice-based approach to understanding this problem is also stated by Sengers et al., (2019). Where the practice-based approach adds its value is that of having the focus on what people do and say. What people do and say and how they interact with a social practice are within the three elements described by Shove et al., (2012).
In line with this reasoning, the practice-based approach is the opposite of that of behavioural sciences, where the focus is on the change of the behaviour of people and not on the people themselves, why people want to change or not (Laakso et al., 2021). In this research, the focus is also on people, the farmers within this pilot study and outside the pilot study. To understand why these farmers want to adopt the new social practice (the innovation), the social-practice approach can be useful because the emphasis is placed on why the farmers want to (not) adopt the social practice of subirrigation from their standpoint.
Many theoretical frameworks are already in place that set out the process of how innovations can be implemented in practice. However, there is a lack of knowledge about the conditions related to the decision whether to (not) adopt these innovations, and thus new social practices. And further, how the probability can be increased to adopt the innovations (Wisdom et al., 2013). To overcome this lack of knowledge, the social-practice approach can be useful because the promoting and constraining

conditions related to decisions, whether to adopt or not, can be discovered from the farmer's perspective and to further increase the likelihood to adopt this new social practice.
In the end, the social-practice approach can contribute to the Diffusion of Innovation Theory (Rogers, 2003) to get a better understanding of why innovations are adopted as new practices.

1.4 Societal relevance

Because The Netherlands is facing droughts more repeatedly, together with the negative economic impact the droughts have on agriculture, innovations are necessary to adapt to this new climatic change. Public authorities from different geographical scales can benefit from it if they gain more knowledge about the effects of this new climatic change and to further increase their knowledge about different spatial adaptation measures they can take to diminish the negative consequences. One of the projects that focuses on this subject, is the KLIMAP project. In this project private and public parties work together in different pilot studies to reach its goal. The goal of this project is to develop pathways to reach a more climate-resilient design of the Dutch sandy soils together with sustainable economic use of it (STOWA, n.d.).
After developing these pathways and studying these pilot studies, the maximum profit from each of its pilot studies in practice should be obtained. To do this, the community is important in the manner if they are willing to adopt this innovation, initiated from the pilot studies, or not. Therefore, it is important to research the conditions that promote or constrain the adoption of the pilot study in Stegeren into their practices. This knowledge that will be obtained in Stegeren can then be used to generate a scaling strategy for this pilot study in the KLIMAP project.

1.5 Thesis outline

This research report contains five chapters, chapter two consists of the theoretical foundation and conceptual framework of this research and discusses the literature on promoting and constraining conditions regarding the social practice of subirrigation. Chapter 3 discusses the methodology together with the research strategy of this research. Included in this chapter are also the reliability, validity and ethical considerations. Thereafter, in chapter 4, more context on the KLIMAP project and the pilot study in Stegeren will be given and the results will be discussed, including the answers to all the sub-questions. Eventually, chapter 5 will present an answer to the main question of this research, together with other main conclusions. At the end of this chapter, these main conclusions will be discussed and the implications, limitations and recommendations of this research will be provided.

2. Theoretical Overview

This chapter begins by describing the literature that is necessary to build the conceptual framework. After giving an overview of the theories that will be used to make the conceptual framework, the same framework will be operationalised by explaining the three elements in-depth and how these elements can be investigated in practice.

2.1 Innovation, adoption, and scaling in climate adaptation planning

The scale and scope of climate change activated the widespread acceptance that it is necessary to adapt to it. Adapting to climate change is not as simple as it seems at first hand. Climate change adaptation (CCA) is an enormous challenge involving different actors from different (geographical) playing fields (Kauffman & Hill, 2021). "Climate adaptation overlaps with initiatives for environmental sustainability, mitigating (or reducing) carbon emissions, and disaster risk reduction, but focuses especially on adjusting to future climate conditions" (Shi et al., 2015, p.191).
To make CCA possible, especially in agriculture, one of the most used strategies is technology research and development (Houghton, Jenkins & Ephrams,1990).
To ultimately develop these strategies, (technological) research will be examined in practice, in the form of innovation.
However, innovations emerge with different threats and challenges. Most of the time the ideas for such an innovation fail. The cause of these failures can vary from internal organizational causes to external related causes (Hunter et al., 2012).
To overcome these failures, pilots could help to do so. A pilot can be described as a project in which an innovative working method or technology is applied on a small scale to gain a broad understanding of the functioning of the innovation (Breman, Vreugdenhil, van Buuren & Ellen, 2017).

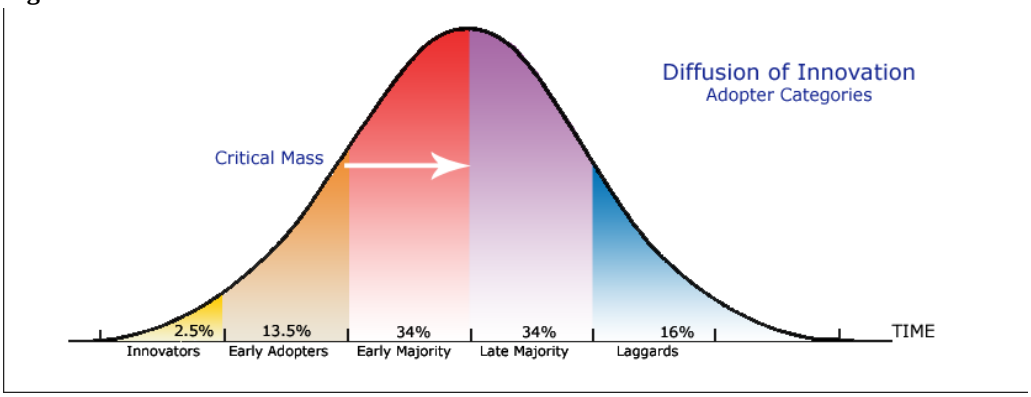
If these pilots are successful in practice, then the next challenge arises. This challenge is to scale up to the size of the perceived problem where the innovation is examined (Woltering et al., 2019). Different categories are used and different definitions are in place on what upscaling entails and how it takes place in practice. Hartmann & Linn (2008, p.8) interpret upscaling as "expanding, replicating, adapting and sustaining successful policies, programs or projects in geographic space and overtime to reach a greater number of people". Concerning agriculture, the International Institute of Rural Construction (2000) in Woltering et al., (2019, p.3) defines upscaling as follows; "it is often interpreted as reaching maximum adoption of a particular technology or practice by as many smallholder farmers as possible".
Nonetheless, upscaling comes with some limitations which vary from a range of factors(conditions) originating from the context of the pilot itself (Dijk et al., 2018). This results in the fact that most pilot studies do not scale up to the broader environment, to realize an impact larger than where the pilot study was initiated (Deiglmeier & Greco, 2018).

Following up on Woltering et al., (2019) and the International Institute of Rural Construction (2000), to realize upscaling of pilot studies and their impact on the broader environment, maximum adoption of these pilot studies is needed by as many farmers as possible. Adoption of innovation can be described as the assimilation of an idea, practice, or philosophy that is new to an adopting person (Timmor & Katz-Navon, 2008). Adoption does not happen from one moment to the next, adoption is a decision that takes place whether people (not) adopt a new practice, idea, or philosophy (Kaminski, 2011). Rogers (2003) explained how this decision unfolds to (non) adoption and the process behind it. This will be explained in the next paragraph.

2.2 Diffusion of Innovation

How these innovations gain momentum and expand over time through a social system, is explained in the Diffusion of Innovation theory (DOI) developed by Rogers (1962). Diffusion can be seen as one of the important processes to make social changes on large scales possible. This is to reach a greater number of people, which is one of the goals of upscaling. The term 'diffusion' itself is explained as " the process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers, 2010, p.10). The model of the DOI theory, figure 2.1, can be seen as a useful change model because the model describes how a technological innovation moves and needs to be modified to fulfil the needs of the different levels of adopters (Kaminski, 2011).
Rogers (2010) described diffusion as a process, which Rogers illustrated with an S-curve. The process starts with a few adopters who are willing to adopt a new idea or practice (the innovation). These are called the 'innovators' who spread the word of the new idea to more people which eventually leads to the development of a critical mass of adopters. Gradually, the innovation becomes diffused among the social system, through the various groups of adopters, until the point when saturation is achieved (Kaminski, 2011). The various groups of adopters are illustrated in figure 2.1.

Figure 2.1: Diffusion of Innovation



Reprinted from Kaminski, J.(2011). Diffusion of Innovation Theory. *Canadian Journal of Nursing Informatics,6*(2). Theory in Nursing Informatics Column. https://cjni.net/journal/?p=1444

Diffusion is thus the **process** of how an innovation spreads within a social system such as groups or a community.
Adoption, on the other hand, is the **decision** of an individual to (not) implement innovations within the system of the individual. This decision is then based on the knowledge, expertise, and persuasion of this individual. The key to adoption is that the individual must recognize the new idea, the practice, as something that has added value in comparison with the previous practice. If this is the case, diffusion is feasible (Wayne & La Morte, 2019).
Besides the difference between process and decision, diffusion and adoption do have some similarities. The level of diffusion can both promote and constrain the process of further adoption because of possible bandwagon effects. A large number of subsequent (non) adoptions in a community can influence the decision of prospective adopters to adopt or not. Moreover, pressure from within the system or society to (not) adopt also plays an important role (Granovetter, 1978).
Thus, the diffusion of innovation can be completed through the decision of an individual to adopt the innovation. This innovation can have different forms varying from ideas to practices.
However, not much information is in place related to the decision whether to adopt or not innovations and how the probability to adopt the innovations can be increased, to make further diffusion possible (Wisdom et al., 2013). To gain knowledge about these adoption issues, the social practice theory can be used. This theory will be described in the next paragraph. In paragraph 2.4, further explanation will be given on how the social practice theory is placed in the field of adoption in this research.

2.3 Social practice theory

The theoretical framework on which this research is based, stems from the social practice theory. The theories of practice originate at least from the time of Wittgenstein and Heidegger. Although Wittgenstein does not talk about ‘practices’, his work contains key features of the theories of social practice (Shove et al., 2012). Practice theories are a set of different theories which all focus on social practices which can be seen as the starting point for a social change instead of the individual (Reckwitz, 2002). These practice theories include different approaches (cf. Hui et al., 2016; Reckwitz, 2012). These approaches see the world “as a compilation of routines performed by people ‘using tools, discourse and our bodies” (Rabadjieva & Butzin, 2019, p.928). According to Reckwitz (2002, p.249), a practice can be seen as a “routinized type of behavior”.
However, to formulate a practice in this way, can be quite dangerous. Because the explanation of Reckwitz (2002) assumes that a practice is in the same line with the habits of individuals, which becomes clear when Reckwitz talks about practices as a block of patterns, where the patterns can be filled with single or large numbers of actions (Shove et al., 2012). In this line of reasoning, Schatzki describes a practice as “a temporally and spatially dispersed nexus of doings and sayings”(Schatzki, 1996, p.89).

Thus, in the eyes of Reckwitz (2002) and Schatzki (1996), a practice can be seen as an entity, which "refers to the interrelated elements of a practice as a recognizable doing and relatively stable" (Maller, 2015, p.59).
Next to a practice as an entity, practices also exist as a performance (Shove et al., 2012). "It is through performance, through the immediacy of doing, that the 'pattern' provided by the practice-as-an-entity is filled out and reproduced" (Shove et al., 2012, p.15). In a practice as a performance, individuals serve as the host of the practice, instead of practices "being the behaviour or qualities of individual people" (Maller, 2015, p.59). The practice of performance is about the integration between elements that are bound to specific moments in a particular situation (Higginson et al., 2015). This integration of elements is important in the alternative definition, the more concise and recent definition of a social practice, which is mentioned by Shove et al., (2012) (Pantzar & Shove, 2010). This definition expresses that practices are based on three elements; meaning, material and competence (Maller & Strengers, 2013).
In this research, I follow the line of reasoning of Shove & Pantzar (2010) to express what a practice is. A practice is about the meaning (why and how individuals attempt things, ideas, and aspirations), material (are all physical attributes, for example, the environmental surroundings), and competence (total body of skills and knowledge required to perform the practice successfully). It is because of the rotation of these three elements, that individuals, as hosts of a practice, can perform practices; the performing of practices contributes to the continuation of these.
Next to the capacities and resources from the individual that are necessary to reproduce/change social practices, other factors(conditions) are also worth mentioning. These are institutional/power-related factors(conditions) that can influence the elements of the social practice of an individual (Shove et al., 2012).
Between entities and performances a relationship is noticeable, practices-as-entities can guide performances and because of these performances entities can be copied or replaced (Warde, 2005). However, this contrast between the two different sorts of practices, entity, and performance, is useful to think about how practices can change. By observing through repeated performances, it can be observed how practices disappear, change or continue (Shove et al., 2012; Warde, 2005).
As Warde (2005, p.141) describes it nicely, practices "contain the seeds of constant change".
The difference between entities and performances is a useful addition to the practice theory to study practices as performances in real life. The distinction between both forms of practices is also functional to express how the combinations of the three elements are enacted and copied (Shove et al., 2012).
Because practice-as-a-performance is about the integration of the three elements and how these three elements contribute to the repetition of a certain practice, it makes it possible to study why practices adapt or fade away over time.

2.4 Positioning of social practice theory in the field of adoption

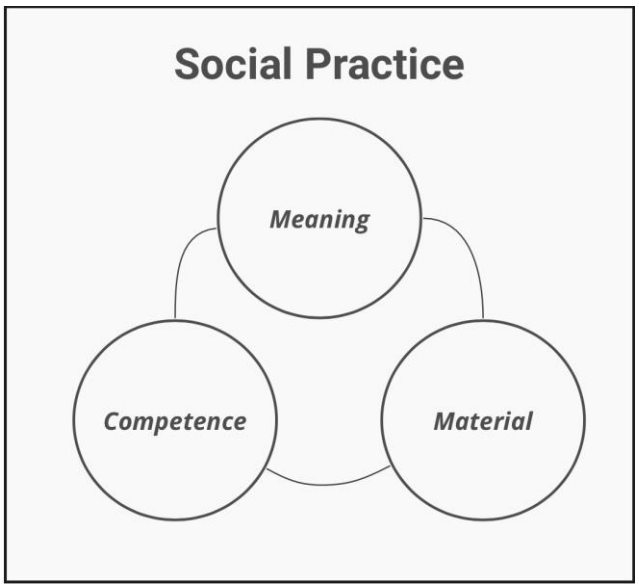
The components of the social practice theory and adoption are, at first sight, not two concepts that connect well with each other. To understand how these concepts connect, it is important to explain how social practice theory is placed within this field of adoption. In this research already two crucial points have been made to explain how social practice theory can be placed into this field of adoption.
The first point that has been made in this research, is the point that adoption is a decision instead of a process. This decision is related to the implementation of innovations in the system of an individual. The innovation in this research is the innovation of subirrigation, which is conducted as a pilot study in practice. By using the social practice theory, this innovation is approached as a social practice.
However, such a decision to implement the social practice of subirrigation in the farmer's system has to be based on something. As stated earlier, in paragraph 2.2, the decision is based on the knowledge, expertise, physical attributes, and persuasion of an individual. Which can be translated into the three elements of the social practice theory.

Then the second important point, that already has been made in this research, steps in; using the social practice theory and more importantly seeing a practice-as-performance to analyse this decision. A practice-as-performance is focused on the integration of the three elements and how these three elements contribute to the repetition of a certain practice.
Not only the repetition of a practice can then be analysed but more importantly; it makes it possible to study why practices adapt or fade away over time. To relate this with adoption, it is possible to study why certain individuals, farmers, in this case, choose to (not) adapt their social practice of irrigation into a social practice of subirrigation. Therefore, placing social practice theory in the field of adoption, enables the researcher to analyse why the adoption of the social practice of subirrigation is successful (why farmers are willing to adapt to subirrigation) and what constrains the adoption of this social practice.
Thus, these two quoted points help to understand how social practice theory is placed in the field of adoption and where the connection between the field of adoption with social practice theory exists. Social practice theory can be seen as a 'mechanism' that enables the researcher to study the decision, the adoption, of farmers related to the social practice of subirrigation. Therefore, to gain knowledge about these adoption-related issues, the social practice theory can be used.

2.5 Social practice theory, theoretical framework

To relate the social practice theory to this research and interpreting a practice as a performance, enables me to study why farmers want to (not) adopt the new social practice of subirrigation. As described in paragraph 2.3 the practice as performance has a focus on the integration of the three elements and how these elements can contribute to a change in practices. A change in the practice of irrigation can happen if these elements of the practice itself change. Changing the elements of social practice happens when a new social practice is adopted.
Adoption, discussed in paragraph 2.2, is the decision of an individual whether to (not) implement innovations, such as new practices, within the system of the individual. This decision is based on individual knowledge, expertise, and physical attributes which are translated into the three elements of the practices of Shove. The theoretical framework of Shove et al., (2012), in figure 2.2, forms the basis for doing this. In this framework, Shove explains which three elements a social practice is based on, and how social practices change because of these elements. These three elements of a social practice are described in-depth and operationalized in paragraph 2.6.
Therefor investigating the three elements of the social practice of subirrigation of the farmers in Stegeren make it possible to discover the promoting and also the constraining conditions these farmers have and why they were willing to adopt the new practice of subirrigation. Besides the farmers who are part of the pilot study in Stegeren, other promoting and constraining conditions for the adoption of the social practice of subirrigation can be found at farmers who have not yet adopted the new practice of subirrigation.

Figure 2.2: The social practice framework



The elements of a social practice adapted from Shove et al.,(2012). This figure illustrates the three elements of a social practice. Meaning can be seen as to why and how individuals attempt things, ideas, aspirations, emotions, norms, and values concerning the practice; Material defines all physical attributes of the practice; Competence is the total body of skills and knowledge required to perform the practice successfully.

2.6 Elements of a social practice and operationalization

As stated earlier, a social practice exists of three elements; material, meaning and competence. These elements interact with each other if a person carries out a social practice, which is in line when approaching a practice as performance. According to Shove et al., (2012) these three elements have an important role to determine if a social practice is carried out successfully or results in failure. A social practice is embedded in the life of a person, the practitioner, when all the three elements are at hand, which makes, for that reason, the execution of a practice possible. The coherence of the three elements of a practice is required for a practice to be successful (Holtz, 2014). To understand what makes the adoption of the social practice of subirrigation successful or constrains the adoption of the social practice, these three elements, and especially the conditions of these three elements of the social practice of subirrigation, have to be investigated in reality. To ultimately come to more detailed descriptions of the elements, the conditions for each element, that promote and constrain the adoption of the social practice of subirrigation.
The next three subparagraphs will explain the three elements more in detail and explain how the three elements and conditions are operationalized. It is important to note that social practices, are most of the time, context-specific and personal (Holtz, 2014) (Schatzki & Cetina, 2001) (Higginson et al., 2015). Therefore specific conditions from the three elements, described in figure 2.3, can differ at points from the conditions that will result from observations and interviews in Stegeren.

These operationalized conditions that are already in place in figure 2.3, are conditions that stem from the literature about subirrigation. It is possible that specific conditions of the elements, that are useful for this research, do not yet exist in the already existing literature about social practices. For each element, some examples will be given of how the element can be operationalized.
On the other hand, the operationalisation of the three elements itself is more generally accepted and is also distilled from a broad range of relevant literature (Frost et al., 2020) (Holtz,2014) (Reckwitz, 2002) (Shove et al., 2014) (Skovdal et al., 2017).

Thus, this research uses the existing literature about the three elements of a social practice in general. Operationalisation of the conditions of the elements of a social practice of subirrigation takes the existing literature as a starting point to further build-up to the social practice of subirrigation specified for Stegeren.
At last, the literature about the conditions will further be merged with a semi-open method to look for other conditions related to the three elements of the social practice of subirrigation in Stegeren.

2.6.1. Material element

The first element, the material element or 'things' is hardly mentioned by Giddens (1984) and Bourdieu (1984). Their focus is on the 'social' part, the 'understanding and know-how' of a practice as described by Reckwitz (2002). Nonetheless, later authors such as Reckwitz (2002) and Schatzki (2003, p. 106) explore and address the importance of how practices are "intrinsically connected to and interwoven with objects". As (Røpke, 2009) stated, nowadays, there is a broad consensus that the 'things' part of social practices is reckoned as the material element of social practices. 'Material' comprises infrastructures, tools, hardware, encompassing objects, and the body itself, all physical attributes to make a social practice possible (Shove & Watson, 2007). This 'list' of what the material element consists of, is the starting point of the material element for this research.
To further operationalize the material element to the level of conditions, different sources of literature, related to subirrigation are used that describe these conditions. For instance; Logemann (2021) described that the technique of subirrigation works well if the land property is located well concerning the groundwater level.
Moreover, the soil type and type of crop are important when conducting subirrigation, since subirrigation can have different effects on the type of crop and type of soil (NPPL, 2020) (Waterschap Limburg, n.d.). At last, Baule et al., (2017) and NPPL (2020) stated that the availability of enough water to run the system of subirrigation is crucial, to begin with.
Further specific conditions of the material element that promote or constrain the adoption of the social practice of subirrigation are stated in figure 2.3. Other conditions, besides the conditions in figure 2.3 will be analysed during this research.

2.6.2. Meaning element

The second element on which a social practice is based on, is the element of meaning. Reckwitz (2002) narrates meaning as mental activities, motivational knowledge and emotions. Shove et al., (2012) summarise this by giving it the name 'meaning element'. Shove et al., (2012, p. 24) use this term to "represent the social and symbolic significance of participation at any one moment". The meaning element is important for a social practice itself since this element also expresses the 'feeling' or association a practitioner has with a social practice. The meaning element expresses the emotions or the feeling of doing the right or wrong thing for the practitioner concerning the social practice. This element can thus be place-bound and personal because it touches on how practitioners feel about carrying out a specific social practice. This 'personal feel' is, on the other side, important to investigate for the social practice of subirrigation because the pilot in Stegeren is also situated and the social and symbolic significance of the participation can differ, in a promoting and constraining way, from farmer to farmer. Therefore, the meaning element is vital to building up this social practice and helps to understand the promoting and constraining conditions that make the adoption of the social practice of subirrigation (not) possible.

Different types of literature describe the conditions of the meaning element related to subirrigation. Related to the economic reasons, Ferrarezi et al., (2015) stated that subirrigation can be beneficial for the costs of labour because subirrigation facilitates automatization which can be seen as a personal (economic) condition to adopt the practice of subirrigation. In Stegeren, for example, different farmers received subsidies to install the subirrigation system on their land. Receiving subsidies results in lower costs which are seen as an important economic condition to adopt the social practice of subirrigation (Bartholomeus et al., 2021).
Moreover, personal ideas and aspirations about income security, C02 emissions, droughts, or climate change can contribute to the fact that a farmer wants to (not) adopt this practice of subirrigation.
At last, the personal value a farmer can have to grow crops of better quality and/or which are less contracted to diseases can be seen as an important condition to adopt this social practice (Ferrarezi et al., 2015)

2.6.3.Competence element

Next to the material and meaning element is the competence element. This element entails the “know-how, background knowledge, and understanding” of a social practice (Shove et al., 2012, p.24). Giddens describes this element as “the practical consciousness, deliberately cultivated skill, or more abstractly, as shared understandings of good or appropriate performance in terms of which specific enactments are judged” (Giddens, 1984 in Shove et al., 2012, p.24). It is important to notice the contrast between the skills of a practitioner to evaluate the practice he or she just carried out and having the skills to perform the practice in the first place.
The skills to evaluate a social practice are of importance to eventually personify the practice by the practitioner after accomplishing the practice for the first time (Warde, 2005). And secondly, having the skills to perform the practice in the first place as Warde (2005) states it, is the knowledge of the practitioner to execute the practice. These skills are necessary to start a social practice.
To further describe the conditions of the competence element, different sources of literature are used to operationalize this element further in relation to subirrigation. For example, Nationale Proeftuin Precisie Landbouw (NPPL, 2020) stated that malfunctioning of subirrigation systems can occur and to use the system itself, a decent level of knowledge is needed. On the other hand, Promeco (n.d.) (a subirrigation installation company) described that the subirrigation system is fairly accessible. If the farmer does know how the subirrigation system functions, this can give the farmer a benefit to operate the subirrigation system on his own, which can be seen as a condition that promotes the adoption of subirrigation (Promeco, n.d.).
In the end, the three elements of a social practice are connected by individuals, the practitioners, when carrying out a practice. The practitioner is considered to be an "empty" container in which meaning and competence are embedded and evolve, and which adopts a material, making the social practice as a composition of elements, complete (Holtz, 2014).

2.6.4.Operationalisation

After describing the three elements of the theoretical framework more in-depth and how these three elements and their conditions manifest and can be recognized in practice, the operationalisation of the social practice theory has been made. Since social practices can be place-bound, personal, and "no generalized systematic account of variables (conditions) exists" (Holtz, 2014, p.2). A full operationalisation of the theoretical framework, in terms of conditions, would not be possible. Because there are always conditions, related to subirrigation, that do not apply to every individual farmer.
This research is not focused on measuring the existence or absence of the social practice of subirrigation but focuses on how the social practice of subirrigation can exist or why the social practice is not present. This means that the social practice of subirrigation can still flourish if not all conditions of an element are recognized in practice.
To research how the social practice of subirrigation can manifest or not, the underlying promoting and constraining conditions of the three elements should be investigated further than the conditions that are stated in figure 2.3. These additional conditions can be found in Stegeren, where the specific subirrigation practice is conducted.

Thus, this research uses the theoretical framework of Shove et al., (2012) to show how the three elements are translated into reality and can be recognized.
In table 2.3 the elements are provided with the characteristics that make the three elements more concrete instead of continuing to exist in their theoretical form. This operationalisation enables the researcher to identify the three elements and their accompanying conditions in real life throughout the fieldwork phase in Stegeren.

Figure: 2.3: Operationalisation of the social practice theory

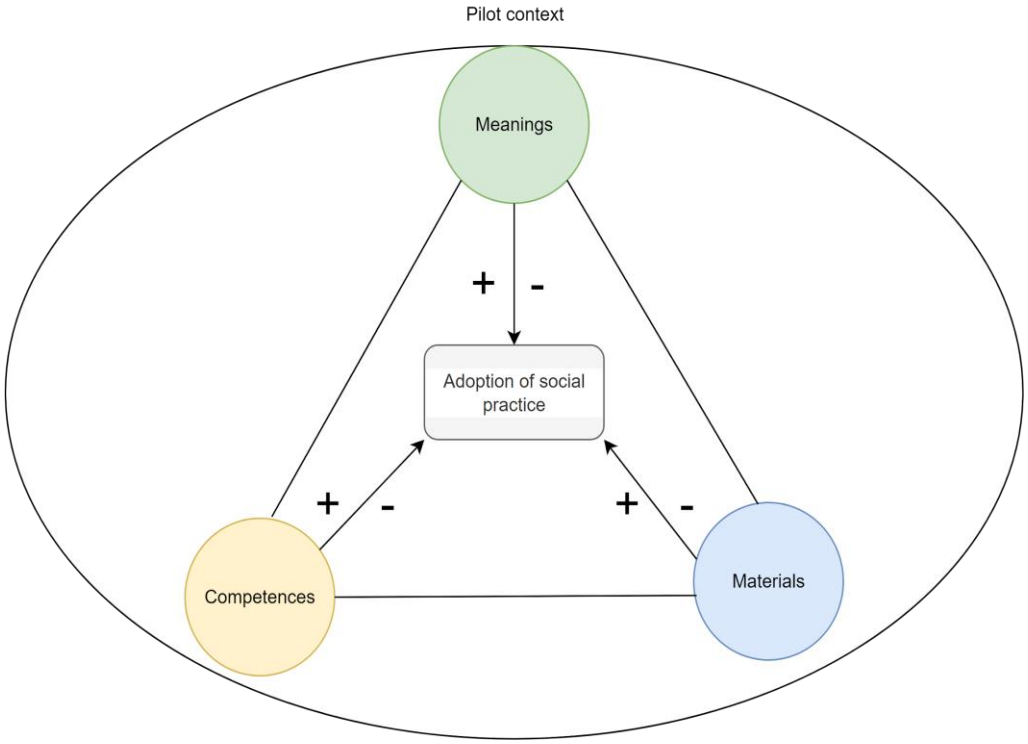
Social practice	**Elements**	**Operationalisation of the elements**	**Operationalisation of conditions of the elements**
Subirrigation	Material	Infrastructures, tools, hardware, encompassing objects and the body itself, all physical attributes related to the social practice.	1. Soil conditions 2. Influence on groundwater level 3. Construction of wells and pipes 4. Availability of water 5. Soil type

			6. Crop health and quality, the spread of crop diseases 7. Location of land property
Subirrigation	Meaning	Social and symbolic significance of participation, ideas, emotions and aspirations related to the practice.	1.Personal value related to economic well-being; investment costs, income (in)security, revenue on crops, labour costs and value of the land property. 2.Personal value related to the climate; climate change, droughts, and C02 emissions. 3. Personal value related to; crop health and quality, the spread of crop diseases
Subirrigation	Competence	Know-how, background knowledge, technique and understanding related to the social practice.	1. Knowledge that determines the functioning of the irrigation system. 2. Skills to manage and operate the system 3. Knowledge of the system when it is (not) useful to use 4. Usability of the system

2.7 Conceptual framework

The figure below portrays the conceptual framework that will be used to structure this research. In this figure, the literature on social practice theory from Shove et al., (2012) forms the foundation of the conceptual framework. The three elements, material, meaning and competence from Shove et al., (2012) are used to investigate what the promoting and constraining conditions are to adopt the social practice of subirrigation in Stegeren. These three elements are pictured in the conceptual framework below.
The concepts of 'promoting' and 'constraining' are visualised by using the + and - symbols for each of the three elements.
Lines are drawn between each element because the elements are interdependent. This also means that elements can influence each other, by having promoting or constraining conditions that can (possibly) influence other elements. Three different arrows are used, for each element, to visualize the promoting and constraining conditions farmers experience concerning the adoption of the social practice of subirrigation in Stegeren. At last, all these conditions are nested within the pilot context.

Figure 2.4: Conceptual framework



To eventually conclude what the enabling and constraining conditions are to (not) adopt the social practice, researching the conditions of each of the three elements is necessary. To make measuring of each element possible, operationalisation is done in paragraph 2.6. Because of the operationalization, a translation happened from the theoretical concepts into reality, whereby conditions can be detected in practice. These detected conditions help to understand the constraining and enabling conditions specified for each element.

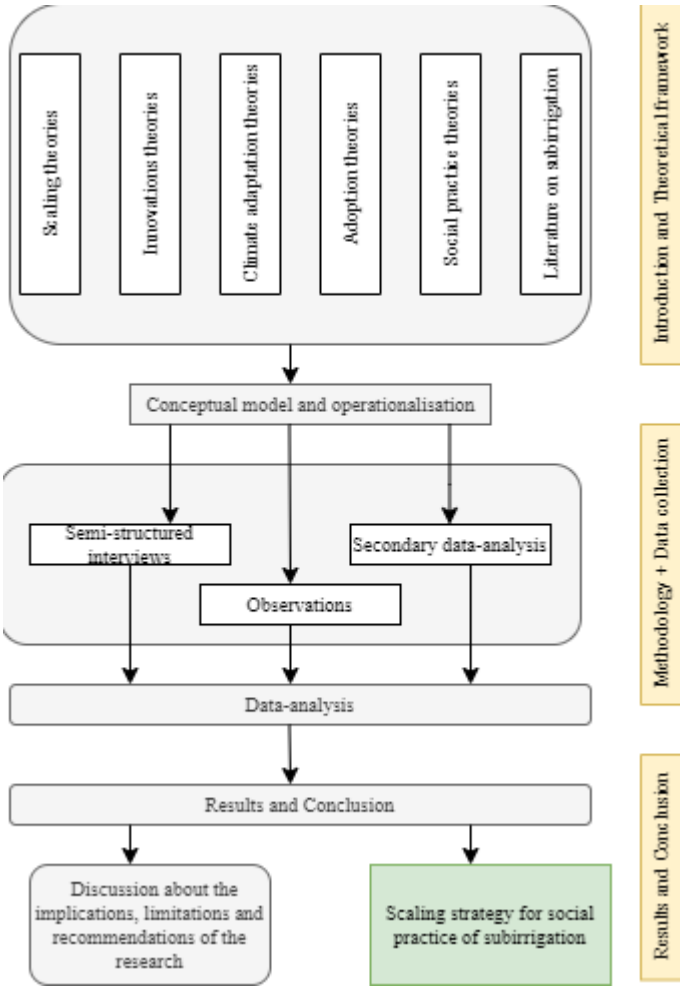
3. Methodology

This third chapter elaborates on how the empirical part of this research was carried out. This chapter starts by explaining how the main research strategy was chosen and further describes the methods that were used to collect the data and how these data were analysed. Finally, the reliability and validity together with the research ethics of this research are discussed.

3.1 Main research strategy

The goal of this research was to develop a scaling strategy for the social practice of subirrigation. To gather the main data for developing this scaling strategy, the researcher used solely a qualitative approach in this research. This entails that the researcher only based his research on qualitative methods. To ultimately achieve the aim of this research, the researcher followed different sequential phases during the research which are illustrated in figure 3.1.

Figure 3.1: Outline of research strategy (Own work)



As stated in figure 3.1, the research commenced with an exploration of different kinds of theories and literature, which later translated into the conceptual framework that was used in this research. Scaling theories are the first kind of theories that were explored, to better understand the 'bigger picture' on how subirrigation can evolve further than only the pilot area where it is conducted. Second, Innovation Theories were researched to recognize how innovations, like subirrigation, could diffuse to other farmers. In the third place, climate adaptation was looked into, to understand and explain the broader topic of where this research and the pilot study are situated.
Next, adoption theories were explored to illustrate the decision of farmers related to the adoption of subirrigation. To interpret where this decision was based on, social practice theories were researched and finally, literature on subirrigation was looked into, to further operationalize the elements that stem from these same social practice theories.

After investigating the theoretical concepts, the researcher used the theoretical framework of the social practice theory from Shove et al., (2012) to further build the conceptual model. After building the conceptual model, the elements of this conceptual model were operationalised into conditions that are measurable and observable in practice.
After the operationalisation of the theoretical concepts, secondary data analysis was conducted. The data that was investigated, regarding the secondary data analysis, are documents and websites related to the Lumbricus project and the KLIMAP project about Stegeren to search for promoting and constraining conditions related to subirrigation. Next to secondary data analysis, observations together with semi-structured interviews were conducted with farmers in Stegeren.
The semi-structured interviews and observations were also used to get a better 'in-depth' picture of the conditions that are important for the farmers related to the social practice of subirrigation; these found promoting and constraining conditions are also used as codes in the codebook which is stated in appendix 6.

After the outcomes of these semi-structured interviews and outcomes of the observations were collected, data analysis was done by the researcher. To ultimately write the results, the conclusion and discussion of this research. This conclusion also incorporated an answer on how the obtained knowledge could be used to develop a scaling strategy for the social practice of subirrigation.
To conclude, to be able to come to the best research outcome, where the outcome is based on different perspectives regarding the subirrigation system, the researcher chose this outline (figure 3.1) for the research.

In general, the overall strategy that this research followed, does fit into one of the research strategy categories as narrated by Van Thiel (2014). The starting point of this research was a single case study-based research strategy. According to Remenyi et al., (1998), a case study-based research approach provides a multifaceted perspective which results in a more comprehensive understanding of the situation (the pilot) that is

being investigated. To meet the multifaceted perspective, different farmers, outside the pilot and in the pilot, were interviewed and observed to get a comprehensive understanding of the promoting and constraining conditions related to the adoption of the social practice of subirrigation in Stegeren.
In addition, a case study approach helps the researcher to carry out empirical research, investigating a present phenomenon which is related to the complexity of everyday life and deriving different sources of evidence (Yin, 1997).
This is a holistic approach that fits well with the complex character of social practices (King, 2019). Since this research was about investigating social practices, especially the social practice of subirrigation, the collection of data on these practices is comparable to an ethnographic methodology (Halkier, 2011).
An ethnographic approach fits well with an explorative form of research which allowed the researcher, in this research, to investigate the routinized aspects of the daily life of the farmers (respondents) and thus an examination of the social practice of (sub)irrigation in their daily lives (Hammersley, 1992).

In this research, the main focus was on one pilot study, this pilot study is situated in Stegeren. Because the research mainly focused on one case study and one social practice, it did help to create a "deeper understanding of the exploring object", where the object was the social practice of (sub)irrigation (Gustafsson, 2017, p.9).
During the research process, a combination of primary data and secondary data was examined. To begin with, the secondary data was distilled from documents and websites about the pilot study of Stegeren in the Lumbricus and KLIMAP project (Lumbricus, 2022) (KLIMAP, z.d.). Primary data were collected qualitatively by conducting interviews and doing field research, which will be further described in paragraph 3.2. This pilot study is a part of the, earlier described, project KLIMAP, which is an ongoing project and therefore this research also had an exploratory character. Because of the exploratory character, this research had an inductive approach.

3.2 Research methods and data collection

To collect usable data in this research, different research methods were used.
Next to earlier described secondary data analysis, semi-structured interviews were scheduled and conducted to gather more information related to the social practice of subirrigation. The choice for semi-structured interviews was made because semi-structured interviews have a pre-established sequence of questions, however, these types of interviews still permit flexibility during those interviews (Clifford et al., 2016).
This flexibility resulted in a less formal manner of interviewing which was necessary to dive deeper into some questions or topics which were more interesting or important to obtain more information about (Drever & Scottish Council for Research in Education, 1995).

Before the commencement of the interviews, each respondent received an informed consent form which is stated in appendix 5. This form allowed the researcher to record the interviews after the respondent signed the form. The recording of the interviews was important because it enhanced the reliability and quality of this research and especially of the data collection process (Berazneva, 2013). Interviews were recorded by using two different devices, this ensured that no problems related to the recordings occurred if one device would not have worked. These recordings were then kept on the researcher's laptop for an additional backup in case both recordings on the recording devices would have been lost. The duration of each interview and observation varied between 60-90 minutes.
To conduct these interviews in the first place, four different interview guides were made which contained the topics that needed to be discussed during the interviews. Since this research is inductive, the topics, in the interview guides, reflected the research questions which were formulated in paragraph 1.2, which defined what information this research wanted to achieve (Van Thiel, 2014).

The selection of the respondents for these semi-structured interviews depended, in the first place, on the fact that this research is linked to the KLIMAP project and especially linked with the pilot study in Stegeren. Therefore, the factors in which respondents were selected were in some way predetermined. The first factor was related to the geographical location of the plot of the farmer. Since this pilot study is situated in Stegeren, a relatively big part of the respondents also have their property in Stegeren.
However, some respondents do not come from Stegeren but are very close to Stegeren. The reason for this is that only five farmers were involved in the pilot study itself which were not enough respondents in the first place for this research.

The second factor that was important for choosing the respondents, is that farmers are using the system of subirrigation. This was fairly simple for the four respondents who are part of the pilot study. However, due to the lack of sufficient respondents within the pilot study, other farmers who do not use the system of subirrigation were also interviewed. The mix of farmers from within the pilot study and outside the pilot study resulted in getting more inclusive answers at the end of this research.
Eventually, this selection of respondents resulted in three different groups of farmers.

The three different groups of farmers that were interviewed for this research were as follows:
-The first group contained the farmers who are involved in the pilot study in Stegeren and already are making use of subirrigation.
-The second group contained farmers who are not involved in the pilot study; however, these farmers do have knowledge about subirrigation and how it functions.
-The last group of farmers who were interviewed contained the farmers who are not part of the pilot study in Stegeren and are not familiar with subirrigation. However,

this last group did not exist in practice since every farmer did have (some) knowledge about the subirrigation system.
Next to these three different groups of farmers, a fourth group was interviewed. This was the waterboard Vechtstromen because, during the interviews with the farmers, it became clear that a crucial relation between the farmers and the waterboard exists related to subirrigation. How this relationship works and why this relationship is important will be further explained in chapter 4.
For each of these four separate groups, interview guides were made; these guides can be found in appendix 1 to 4. The respondents that participated in the interviews and observations are listed in figure 3.2.
Next to secondary-data analysis and semi-structured interviews, field research in the form of observations was conducted. Doing observations is another qualitative method to collect data. Doing observations fits well with the earlier described inductive approach in paragraph 3.1 (Van Hulst, 2008). The observations that were performed during this research were meetings with the farmers who are involved in the pilot study in Stegeren. During those meetings, the researcher tried to recognize and reflect on the conditions related to the three elements.
Next to these meetings, the researcher observed the farmers who are not part of the pilot study. Observations took place after the interviews with the farmers. The observations were useful to get a better picture of what was told during the interviews. During those observations, the conditions, cited in the interviews, got more context by seeing this in reality. For example:
The farmer showed the researcher their land property in relation to the groundwater level, showed how the subirrigation system works and further illustrated what the farmer said during the interview. To organise the observations, the researcher took anecdotal notes and photos to get a record of all observations.

Figure 3.2: Overview of respondents used for interviews and observations

Date *time*	**Interview number:** Name	**Occupation** *(involved in KLIMAP pilot study)*	**Type of irrigation**
18-05-2022 *13.30-14.30*	**Interview 1:** Hendrikus Spoelman	Farmer *(yes)*	Subirrigation and sprinkler system
18-05-2022 *15.00-16.00*	**Interview 2:** Evert Kremer	Farmer *(yes)*	Subirrigation and sprinkler system
18-05-2022 till 19-05-2022 *17.00-10.00*	**Interview 3:**Visscher	Farmer *(no)*	Sprinkler system

19-05-2022 *10.00-11.30*	**Interview 4:** Maarten Paarhuis	Farmer *(yes)*	No irrigation, only SAWAX weir
19-05-2022 *13.00-14.15*	**Interview 5:** Hemstede	Farmer *(yes)*	Subirrigation and sprinkler system
19-05-2022 *15.15-16.30*	**Interview 6:** Robert Geertman	Farmer *(yes)*	Subirrigation and sprinkler system
30-05-2022 *11.00-12.00*	**Interview 7:** Martin Nijkamp	Farmer *(no)*	No irrigation
30-05-2022 *13.00-14.00*	**Interview 8:** Jan Willem Hekman	Water level manager at waterboard Vechtstromen *(no)*	Not relevant
30-05-2022 *15.30-16.40*	**Interview 9:** Han Schukkert	Farmer and co-owner company at Schukkert *(no)*	Sprinkler system
30-05-2022 *16.50-17.45*	**Interview 10:** Bennie Seinen	Farmer and company director at Schuttert *(no)*	Sprinkler system

3.3 Data analysis

Before the analysis of the data, the gathered data had to be ordered systematically. Systematically ordering data can help to analyse the data in a more structured manner. After structuring the data, the data analysis took place.
The analysis of the secondary data occurred by using the method of content analysis. Content analysis is used to analyse the presence of relevant concepts, words or other themes in qualitative data which were related to this research (Harwood & Garry, 2003). The documents that were used for the content analysis are all related to the pilot study in Stegeren which are mentioned in the Lumbricus and KLIMAP projects.

The analysis of the semi-structured interviews started with transcribing the recordings of the interviews. After the transcriptions of the interviews were finished, the transcriptions were uploaded into ATLAS.ti.
This is a research tool used for coding the transcriptions of interviews. The coding process is a critical step in the research process and especially in the data-analysis part (Bryant & Charmaz, 2010). In the process of coding different codes are assigned to different parts of the gathered data. This makes it possible to subtract different patterns

throughout the whole data set and therefore makes the data more uncluttered and systematic (Cope, 2010).
Moreover, coding helps to give certain amounts of qualitative data a meaning concerning this research. By doing this, the researcher was able to compare and analyse different data sets.
Generation of the codes took place via an inductive and deductive approach.
The reason for this is that not much research is done and not much literature is in place about the social practice of subirrigation and how to upscale this social practice to a larger area. Therefore some codes as stated in the codebook in appendix 6 derive from (during) the interviews themselves, which is the inductive approach to coding. An inductive approach to coding is included in this research because, as described in paragraph 2.6.4, there are always conditions related to subirrigation, that do not apply to every individual farmer. This means that new codes were discovered during the interviews and observations which were valuable enough to take into account. Codes that were already in place for the process of coding derive from the conditions for each element, as described in figure 2.3. These conditions were used as separate codes to make the analysis of the data easier, which can be seen as a deductive approach to coding.
After the completion of the coding process, ATLAS.ti was used to generate the output of the coding documents for further analysis.

3.4 Reliability and validity of the research

After the explanation of the research strategy, research methods, data collection, and data analysis, two other elements, namely; reliability and validity are also important to discuss. These two elements are also vital when conducting research and both focus on different aspects of the research, however, the relation and difference between both of these concepts are in a practice not easy to recognize (Van Thiel, 2014).

3.4.1 Reliability

To achieve reliable research, two important aspects of reliability had to be met, namely: accuracy and consistency (Van Thiel, 2014). The more accurate and consistent the conditions, which were measured in this research, the more precise and representative the results will be. In relation to this explanatory research, this means that “a high level of reliability means that the explanation offered is most certainly the right one” (Van Thiel, 2014, p.48).
To ensure accuracy in this research, the researcher had peer-checked the interview guides, the codebook and the conditions to measure the social practice of subirrigation. To guarantee that all conditions, the interview guide and the codebook were as correctly and precisely as possible and also to ensure that a clear distinction was made between each condition.

Achieving the second aspect of reliability -consistency- can be much harder. Consistency stems from the idea of achieving repeatability of the research; this means achieving the same results under the same circumstances with the same measurement tools (Van Thiel, 2014). To enhance the reliability of research, repeatability is a good way to do so because the repeatability of research confirms that the results that have been found in the research are indeed right.
However, in social sciences, the research is mostly centred around people, as something to get information from or as a unit that is being analysed.
According to Van Thiel (2014), people can learn from the past and can change their attitude toward the research object which means that other results can be produced if the same research is conducted again. This could also happen in this research, therefore different steps were taken in this research to guarantee the consistency of this research.

To begin with, each step that was taken in this research should be described in detail. This process started with the description of what is considered to be adoption and how adoption took place by referring to the three elements of Shove et al., (2012). The next step was to describe these elements separately in detail and explain what conditions each element entailed, also to measure a change in these elements. By giving these explanations, descriptions of the elements, and how to measure these, the repeatability and therefore consistency of this research were achieved. Repetition of this research under the same conditions would then hopefully develop the same results, this method is called 'replication' by Van Thiel (2014).

3.4.2 Validity

A case study-based research strategy comes with some implications related to validity, these implications need to be approached. Validity falls apart into two categories: internal validity and external validity (Buntins et al., 2017).
Internal validity entails the cogency of the research itself. If the results from the research represent the population that is studied. Important is to see if the theoretical framework has been operationalized in an adequate manner (Van Thiel, 2014).
To ensure the internal validity of this research, meetings with the supervisor and co-supervisor have taken place to ensure the adequacy of the researcher's conceptual framework and how this conceptual framework was further operationalised.

External validity relates to what extent the research can be generalized (Van Thiel, 2014). However, in a case study-based research strategy, a small number of cases can threaten the external validity because the case can be unique or the results from the case study are only related to the context of this case study (Flyvbjerg, 2006). This issue also applied to this research, where the focus was also on one case.
To tackle the problem of a small number of cases, different methodological solutions were used to overcome the biases of a single case study. These solutions helped to improve the internal and external validity.

The first solution was triangulation, where different ways of collecting and processing data were used to come to valid research results. The form of triangulation in this research was 'methodological triangulation'. This form is used when different data collection methods are used to study one specific case (Turner & Turner, 2009). These methods that were used in this research are already described in paragraph 3.2. Because all methodological approaches have their pros and cons, which makes it adequate to use different data collection methods and sources (Diefenbach, 2008). Because of the use of different data collection methods and thus using triangulation as an approach in this research, as much information as possible was gathered to ensure that this gathered information was valid, disregarding the use of a single case study.

The second methodological solution that was used, to counter the problem regarding the use of a single case study, was the solution of distinguishing the case study into smaller units, or sub-units, known as a layered or nested design (Yin, 2008). In the case study of Stegeren, subunits were made according to the farmers and the water level manager from the waterboard Vechtstromen, who were approached to do interviews and observations. The total group of farmers was initially divided into 3 groups: farmers who are part of the pilot study, farmers who are not part of the pilot study in Stegeren with knowledge about subirrigation and farmers who are not part of the case study and do not have or barely have any knowledge about subirrigation. Finally, it is important to put the results of this research into perspective, in the context of the case study. This research did not aim to offer generalizations, where a quantitative approach would be more appropriate. The aim was to generalize on a theoretical basis instead, which fitted well with the qualitative approach in this research.

3.5 Research ethics

Collecting data in the field of social sciences takes place by conducting this data from respondents. Different ethical considerations had to be made considering the handling of this data. To take care of the handling of data during the research process, five different ethical rules were considered. These five rules stem from the Economic and Social Research Council (Van Thiel, 2014). These five rules will be described and further explained on how this research embedded these rules to guarantee ethically correct research.
The first rule entails that respondents need to be notified about the goal of this research, where the research will be used for and the methods used in this research related to the respondent (Wester, 2011). In this research process, emails and phone calls were used to invite respondents for the interviews and observations. During these phone calls or in the e-mails, respondents were informed of the purpose of this research, the methods that were used to get data from these respondents and where this data will be used for. Moreover, before the invitation of the respondents for the interviews and observations, an advance notice was made by René Nij Bijvank from Waterschap Vechtstromen, to notify the farmers that they were asked for an interview.

Secondly, the participation of respondents in this research should be on a voluntary basis (Silverman, 2017). In this research, potential respondents were completely free to refuse participation.
In the third place, the confidentiality of the respondents' information and the anonymity of the respondents should be appreciated (Silverman, 2017). Since this research was focused on the social practice of subirrigation, a policy-related issue, no personal interests or problems are related to this.
Therefore, the confidentiality of the respondents' information was not problematic in this research. Moreover, during the interviews, respondents always had the chance to refuse questions if the respondent thought it was too personal or too confidential to share. To ensure anonymity in this research, respondents were asked, before the interviews and observations, if the researcher was allowed to use names in this research. Nevertheless, it was likely that respondents do know each other, despite the anonymity. Since each respondent lives close to each other in a small area and some are part of the pilot study itself.
The fourth rule entails that any harm to participants of the research should be circumvented (Silverman, 2017). This principle required that the research was conducted in such a way that it minimises any risk or harm to the respondents. To ensure this principle in this research, the communication on how this research was conducted to the respondents was important and further how this information can be used by third parties, for example, KLIMAP.
At last, "the independence of the researcher must be clear and any conflicts of interest or partiality must be explicit" (Silverman, 2013, p.315). Since this research was a master's research project, no personal interests in the results of this research were present. Moreover, the research was under the supervision of the Radboud University which also had no particular interest in the outcome of this master's research project.

4. Results

In this research, the researcher investigated which conditions related to the three elements of the social practice of subirrigation promote and constrain the adoption of this same social practice in Stegeren. And further, how these promoting and constraining conditions can contribute to developing a scaling strategy for this social practice of subirrigation in Stegeren. In this chapter, the found promoting and constraining conditions for each element will be described.
After that, the following three sub-questions will be answered:

-*Which conditions related to the 'material' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?*

-*Which conditions related to the 'meaning' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?*

-*Which conditions related to the 'competence' element promote or constrain the adoption of the social practice of subirrigation in Stegeren?*

To further explain how this knowledge on the promoting and constraining conditions of the social practice of subirrigation can help to develop a scaling strategy, the fourth and last sub-question will also be answered:

-*How do the promoting and constraining conditions, related to the social practice of subirrigation in Stegeren, contribute to developing a scaling strategy for this social practice?*

To answer all four sub-questions, the analysis of the gathered data will be discussed to ultimately form a final answer. The combination of all these paragraphs, concerning the sub-questions, can be considered as elements to ultimately answer the main question of this research in chapter 5.
However, before the analysis of the data will be discussed and the sub-questions will be answered, the first paragraph will provide more context on KLIMAP, the pilot study in Stegeren and how this pilot study was initiated. The reason for this is to give a better overview of where and how this research developed.

4.1 Context on Stegeren

To understand how the KLIMAP project together with the pilot study in Stegeren was initiated, it is important to give a bit of (historical) background first.
The KLIMAP project is the successor of an earlier mentioned project in this research, namely the Lumbricus project. The Lumbricus project was a cooperation programme which lasted from 2016 till 2020. The project involved different stakeholders, for example; research institutes, regional parties and local farmers and land management

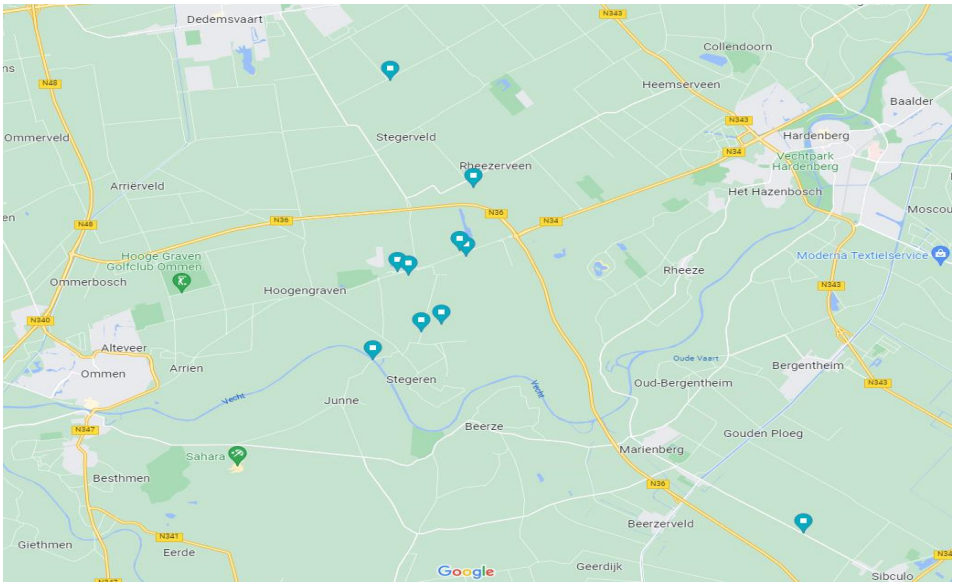
organisations. This project had different goals related to fresh water supply, water quality, climate adaptation and water security. The main goal of the Lumbricus project was the development and implementation of climate-robust water- and soil system on the watershed level. To reach this main goal, different innovative measures were implemented on the level of the soil, water and substrate (de Wit et al., 2021). One of these, so-called 'proefgebieden' (translated as test areas), in the Lumbricus project, was Stegeren. In Stegeren, the partners of the Lumbricus project researched, together with the local farmers, what the best combination of measures was to create a climate robust soil and water system. This intensive cooperation between the local farmers, local representatives of the waterboard and researchers lasted for three years. During these three years, different climate robust measures were implemented, for example; subirrigation, Sawax-weir and an experiment with earthworms. During the Lumbricus project, these measures were monitored not only by the researchers and representatives but also by the local farmers, which is called participatory monitoring. Because of this form of monitoring, a fruitful process of collaboration, knowledge exchange and learning together originated. This was seen as a positive process for all who were involved in Stegeren; this resulted in more useful insights regarding a climate robust water- and soil system.
To continue this fruitful participatory process in Stegeren and to gain more insights related to climate robust water- and soil systems, the case of Stegeren was continued in the KLIMAP project as a pilot study. This fruitful collaboration between local farmers and other representatives was one of the reasons to continue with Stegeren in the KLIMAP project since all parties involved recognized the added value of the participatory collaboration (Aarnink, 2021).
This participatory process, formed in the Lumbricus project, is in line with the philosophy of the so-called 'Ontwikkelpaden' in the KLIMAP project. An important feature of the 'Ontwikkelpaden', which is central in the KLIMAP project, is that there is a long-term dynamic, participatory process whereby different parties work together to identify promising development directions which can be switched to. As stated earlier, this participatory process is also recognizable in the pilot study of Stegeren. Next to this successful participation of the local farmers, one reason to continue in the KLIMAP project with Stegeren is that the Lumbricus project turned out to be too short. Further, learning about these measures, and increasing knowledge and insights about these measures are in line with the main goals of the KLIMAP project and therefore also in Stegeren. At last, most of the investments in measures, regarding Stegeren, were made during the Lumbricus project and therefore continuing with Stegeren in the KLIMAP project can be seen as cost-efficient (Breman & Bartholomeus, 2020).

As stated earlier, one of these promising development directions (measures) that was initiated in Stegeren, during the Lumbricus project, is the level-controlled drainage system also known as the system of subirrigation. Already during the Lumbricus project, five different farmers were approached to take part in this experiment, regarding subirrigation. This resulted in the pilot study in the KLIMAP project.

However, on the land property of one of these farmers, location B in figure 4.1, no drainage system with subirrigation is placed. Instead of subirrigation, a SAWAX- weir was placed. Nonetheless, for this research, it is still valuable to include this farmer (van Bakel et al., 2019; van den Eertwegh et al., 2020b). How these five farmers from the KLIMAP pilot study are located in the area of Stegeren, is illustrated in figure 4.1. To carry out the pilot study in Stegeren, different parties are involved. The following parties contribute to the pilot study in Stegeren, where each party has their responsibilities and tasks: Waterschap Vechtstromen, local farmers, KnowH20, WUR, and KWR water. Next to the five farmers in Stegeren, four other farmers and the water level manager from waterboard Vechtstromen were approached for interviews and observations. How all the nine farmers and the water level manager are placed in the area of Stegeren is illustrated in figure 4.2 with a blue mark.

Figure 4.1: Positioning of farmers in the pilot study in Stegeren (source: KLIMAP)

Figure 4.2: Positioning of all respondents in and around the area of Stegeren (own work)



4.2 The material element of the social practice of subirrigation

This paragraph will describe the promoting and constraining conditions related to the material element of the social practice of subirrigation, to ultimately form an answer to the first sub-question of this research. To commence, a clear division can be made between the conditions of the material element. This division is made since it became clear, during the interviews and observations, that the conditions of 'soil and non-soil' are of such great importance that they cannot be seen as only two conditions but can be split out to more soil-related and non-related soil sub-conditions. A third condition that is important for the material element is the condition of 'crops', This condition is also split out into more sub-conditions in this paragraph, to describe the possible influence they have on the adoption of subirrigation in Stegeren. The condition of 'crops' could be seen as a non-related soil condition, however due to the importance of the condition of 'crops', the researcher chose to split this into a separate third condition.
Therefore, the division of this element stems on three separate conditions: soil-related conditions, non-related soil conditions and crop-related conditions. This division will also be used to describe the promoting and constraining conditions for the material element of the social practice of subirrigation.

4.2.1 Soil-related conditions

After analysing the gathered data of observations and interviews with the ten respondents, some important soil-related conditions of the material element of the social practice of subirrigation became apparent which makes further adoption of this social practice possible or can constrain further adoption of this same social practice.

Soil type, condition of the soil and the capillary function

To begin with, to successfully implement the system of subirrigation, soil type and the corresponding soil condition is of great importance. This soil condition exists, in first instance, of the capillary function and the permeability of the soil. The capillary function of the soil is when the water rises against gravity through concatenated small cavities (pores) between the soil particles, this gives the groundwater the possibility to rise to the roots of the crops which are mostly located just beneath the surface of the land. This capillary function then depends on the type of soil the farmer has. The permeability entails how water and air can move through the soil.
Almost every farmer, KLIMAP related and non-KLIMAP related, mentioned the importance of the type of the soil and the associated capillary and permeability function of the soil.
For example, KLIMAP-farmer Evert Kremer mentioned that also: *"The capillary capacity of the soil is a very important factor I think."*
KLIMAP-farmer Hendrikus Spoelman said the following on permeability:
"The permeability of the soil must be optimal, otherwise the (subirrigation) system will not work properly, you have to make sure that it is right."

Next to the capillary and permeability function of the soil, the quality of the soil also depends on where the soil itself consists of.
Both farmers, KLIMAP and non-KLIMAP related, are aware of how important the soil is for the farmer and their agriculture company.
However, improving your soil to increase its condition of it, is difficult to do.
Martin Nijkamp, non-KLIMAP farmer, said that also during the interview, where he stated that he wanted to improve his soil with fertilization. However, to improve the soil it can take decades to see the result of this same fertilization.
Therefore the type of soil in Stegeren is seen as a given thing by the farmers.

In the area of Stegeren, the soil is mostly sandy. Sandy soils are known for the fact that these soils have a high permeability grade, this means that this type of soil does not have a proper water-retaining layer to retain the water that is being supplemented by the subirrigation system. This is also mentioned by KLIMAP-farmer Hemstede: *"It's not like the other plot where the cows graze where it's pure sandy soil. Because there is not a layer where you can keep the water. Because the water goes straight back, that makes no sense."*
This means that farmers are bound to the type of soil where they could install the subirrigation system.

Other farmers who have implemented the subirrigation system also stress the fact that having a good type of soil is crucial for the proper functioning of the subirrigation system, this improves the permeability of the soil and the capillary function.
Hemstede, KLIMAP-farmer stated that as well: *"The soil is the most important part"*
And Jan Willem Hekman, water level manager at waterboard Vechtstromen stated the following on sandy soils and their permeability:
"We have now chosen Stegeren here, but it is a very sandy area, so that is why the water flows away very quickly."

Thus, the type and condition of the soil can be both a promoting and constraining condition. It depends on what type of soil a farmer has and in what type of condition this soil is. However, as mentioned earlier, most of the soil in Stegeren is sandy. This means that the permeability of the soil is high, which is not desirable to have a good functioning subirrigation system. Nonetheless, the interviews and observations with farmers who have installed the subirrigation system had a good enough soil type and condition to make the system work. The working of the subirrigation system therefore can differentiate for each particular farmer. Therefore, this sub-condition can both be seen as constraining and promoting the adoption of subirrigation. It can be seen as constraining because the farmers are bound to which plot they want to subirrigate. On the other hand, this sub-condition can be seen as promoting since implementing the system in an area, other than Stegeren with an overall better soil type and condition, would ease the adoption of the subirrigation system.

Fertilization of the soil

Next to the sub-conditions of the soil type and its condition, the fertilization of the soil is also important. During different observations and interviews with KLIMAP and non-KLIMAP farmers, farmers indicated that when the ground was fertilized, it was almost necessary to use their sprinkling system. The reason for this is to make the most profit from their fertilization and to reduce emissions, the moistening of the fertilizer is necessary. This could happen by rain or by using the sprinkler installation. Therefore, the farmers think that the use of the subirrigation system for this is not applicable because the water will come from beneath and by doing that the fertilization cannot be moistened. This point is also mentioned by KLIMAP-farmer, Evert Kremer:

"What you're missing a bit is that what we also did a few times when you apply the fertilizer then sprinkle it right at the back, then that the fertilizer works a lot better in my opinion. And the question is whether that is also the case with subirrigation that you miss this advantage of subirrigation a bit."

KLIMAP-farmer, Robert Geertman, said the following on the fertilization of the soil:

"You can simply imagine that if it is 25 or 30 degrees and that fertilizer is on top of it, even if the substrate is still reasonably moist. That does not have the same effect as you put a rain installation (sprinkler system) over it."

Therefore, fertilization of the soil can be seen as a constraining sub-condition of the material element for the adoption of the social practice of subirrigation since farmers still have to use their sprinkler system to make the most profit from their fertilization. However, it depends on the decision of the farmer, if the farmer wants to moisten their fertilizer since not every farmer makes use of a sprinkler installation and still fertilizes their plots.

The flatness of the ground level (maaiveld)

The last sub-condition that is soil related, is the flatness of the ground level (translated as; maaiveld). A reasonable flatness of the ground level is necessary to let the subirrigation system work in a good manner. Too much height difference in the plot can result in a situation where it is difficult to create a stable groundwater level at the plot level. Therefore the equalization of the plot to install the system of subirrigation will contribute to an optimal function of the subirrigation system.

This is also stated by KLIMAP farmer, Evert Kremer:

"Yes, I think flatness for a plot is also important of course. So such a plot (with height difference) itself will work a little less well, I think, I expect."

Also Hemstede, KLIMAP-farmer said that:

"It (subirrigation) will be difficult to do when the plot is not straight."

This can be seen as a (light) constraining sub-condition for the adoption of the social practice of subirrigation since not all farmers have a reasonably stable plot.

On the other hand, stabilization of the plot is a solution to make the instalment of the subirrigation system still possible. This situation also happened at Hendrikus Spoelman, KLIMAP-farmer, where they equalized the plot after the subirrigation

system was placed: *"A plot is levelled after the construction of the drainage. Because it was quite yes, it wasn't nice and flat anymore."*
Thus, the flatness of the ground level can be seen as a (light) constraining sub-condition of the material element. Nonetheless, it is a condition which can be fixed relatively easily. However, the disadvantage is that it will cost the farmer extra money to realize the instalment of the subirrigation system on the plot.

4.2.2 Non-related soil conditions

After describing the soil-related constraining and promoting conditions for the material element, this sub-paragraph will describe the promoting and constraining non-related soil conditions.

The height of the plot in relation to the Vecht
This condition entails the height of the plot of the farmer in comparison with the river the Vecht. The Vecht, as stated in figure 4.2, is the river that supplies the water for the subirrigation system in Stegeren. The further the farmer's plot is from the river, the higher the farmer's ground and vice versa. This means that some farmers have relatively dry ground and other farmers relatively wet ground. The position of the farmer can both be seen as a promoting and a constraining sub-condition for the social practice of subirrigation. For example, Han Schukkert, non-KLIMAP farmer, said the following about the positioning of plots:
"I think it depends, on where you are, because I think if you are on a very high head(plot location) and you are quite far from NAP, then I think well, as it is for me, it's almost impossible, doesn't even seem realistic to me, or you have to pump your ditches full. Yes, so then you get those kinds of scenes and then it is still impossible."
Thus, according to this farmer, when you are placed on very high ground, it can still be very hard to raise your groundwater level by using subirrigation since the water source is too far away.
On the other hand, farmers that have their plots on high ground can be willing to invest in the subirrigation system to secure a constant flow of water to moisten their plot.

When placed relatively low in comparison with the Vecht, farmers can both be willing and not willing to invest in subirrigation, this is also the case with KLIMAP-farmer Hemstede and non-KLIMAP farmer Han Schukkert. KLIMAP-farmer Hemstede, has a relatively low land but also installed the subirrigation system and mostly uses the system to drain water to the ditches when the plot is too moist. On the other hand, Han Schukkert also mentioned that:
"Our plots are actually quite low, so we actually have pretty heavy (good water retaining) ground, so my urgency isn't there."
This means that because of the low placing of his plots, his land is relatively wet and therefore is subirrigation not that appealing to install.

Concluding, the height of the land property in relation to the Vecht can be seen as a constraining sub-condition as well as a promoting condition. It depends on what the farmer wants to do with his plot. For example: draining water if the land is placed relatively low or because the plot is already placed low, no subirrigation system is necessary. The same applies to plots which are further from the river the Vecht and thus are higher plots.

Availability of surface water

After the interviews and observations it also became clear that the availability of surface water is crucial for the functioning of the subirrigation system. This crucial sub-condition is also coined by every individual KLIMAP-farmer.
For example, Hendrikus Spoelman said the following:
"That supply of surface water, that just has to be a fact, If you don't have it, you can forget it. Then you just have to use the sprinkler system, that's your only option."
KLIMAP-farmer Hemstede also stated the same answer on the question if surface water is necessary: *"Actually yes, groundwater is not possible."*
The reason that groundwater is not possible to use for the subirrigation system is also provided by KLIMAP-farmer Hemstede:
"In principle, you should not have groundwater. That doesn't work. There is too much iron and manganese in it and that will block your drainage. So the best is with water from the Vecht, what we have here."
And KLIMAP-farmer Evert Kremer:
"But like in this area there is a lot of iron in the groundwater, what's that going to do? Your drains are getting clogged"

Thus, the availability of surface water is crucial to make the adoption of the social practice of subirrigation possible in this area and can therefore be seen as constraining since not every farmer has access to surface water in the area of Stegeren in the first place.
Moreover, this surface water is provided to the farmers by the waterboard of Vechtstromen every day. However, the waterboard has a maximum capacity of surface water that the waterboard can provide to the area of Stegeren. This became clear after the interview with Jan Willem Hekman, water manager at waterboard the Vechtstromen:
"We ask for water, so to speak, and that goes in cubic metres. And if I need 4 cubic metres today and then they deliver 4 cubic metres and if it has to be 10 cubic metres because that is the max for us. Then they just deliver 10 cubic metres until they say at the IJssel, it is just getting too low and we can no longer deliver and then the water flow stops in our area very quickly"

Besides the problem of access to surface water for farmers who want to adopt the social practice of subirrigation, a bigger constraining sub-condition occurs if the waterboard cannot deliver surface water at all to the area of Stegeren. Since the waterboard can deliver a maximum of 10 cubic metres of surface water every day.

This means that farmers in Stegeren who want to adopt the social practice of subirrigation, are not able to because the maximum water capacity is already reached in Stegeren. This is also stated by Jan Willem Hekman:
"I've talked to more farmers who said in the beginning, we're not participating in this(subirrigation), but they're actually interested now, because they see how it works. But when I come back to the supply piece, yes, it should also be possible.
And if I look at the catchment area, what I have, that piece of catchment area, it's just at its maximum. And it is possible to do more, then you will have to replace some kind of pumps, for example. To increase the water capacity, but then you are even more dependent on the supply, so from the supply that comes from IJssel".

Thus, this means that to increase the capacity of the flow of water, new or smarter pumps and systems have to be installed. However, these costs normally are divided between the waterboard and the farmers. Jan Willem Hekman quoted this also:
"What I understand is that it is partly paid for by the farmers, partly by the water board, so it is not entirely from the water board, but not entirely from the farmers either."
Therefore, the replacement of pumps can result in extra costs for the farmers, which is also an indirect constraining sub-condition related to the adoption of the social practice in Stegeren.

At last, subirrigation seems less efficient than thought in the beginning and takes a relatively big part of the water supply in the area during the dry periods. The reason for this is that the subirrigation system keeps using water the whole year-round. This means that using the subirrigation system in dry periods, together with the sprinkler system, seems not that efficient.
The water level manager, Jan Willem Hekman also confirmed this and questioned if the subirrigation system is a replacement for the sprinkler installation:
"In the dry periods, then they(the farmers) also use the sprinkler irrigation at the side and that level-controlled drainage that is just running. That system continues to run, once you set that up, it continues to run. If you are going to turn on the sprinkler irrigation next to the subirrigation system, then you really have a few extra pumps that take water away. I think that in the dry periods the sprinkler system will be necessary, because you may not have enough water then by only using the subirrigation system"
These above-mentioned constraining sub-conditions can lead to the following consequences if more farmers want to adopt the social practice of subirrigation in Stegeren without increasing the water supply from the Vecht.
- No new farmers can install the subirrigation system
- Farmers who already have the subirrigation system will have less water
- Farmers with sprinkler installation will have less water to sprinkler their plots

Ownership /tenantship of the plot

Besides the plot height in relation to the Vecht and the availability of surface water, the ownership or tenantship of the plot is also an important sub-condition. Different non-KLIMAP farmers have stated that one of the reasons why they do not want to adopt the social practice of subirrigation, is because the farmers are tenants of a particular plot they use for their crops or trade plots with different farmers. This sub-condition also applies to non-KLIMAP farmer Visscher. During the observations and conversations, the farmer stated that he will not install the subirrigation system on the plot because he is a tenant of that plot and not the owner. This constraining sub-condition is also mentioned by non-KLIMAP farmer Martin Nijkamp:

"I also have other pieces of plot, but I won't be adding them (subirrigation) any time soon because I might trade them with another farmer in the future. From the house lot I know that I will keep it anyway."

And on the question if the farmer would install subirrigation on a rented plot, KLIMAP-farmer Maarten Paarhuis answered the following:

"No, you won't do that. I think that's partly why sprinkler irrigation is still by far the favourite manner of irrigation [...] and with a sprinkler installation you can go there (to the plot) in no time and with the subirrigation, you can't just take that with you."

Thus, if farmers want to adopt the social practice of subirrigation, they will apply it to plots they own and will not apply it to plots they rent or exchange with other farmers. During the interviews, it became clear that every farmer, except one, is a tenant of different plots. Therefore, the possibility, in terms of available plots for subirrigation, shrinks. This leads to that the tenancy of the plot can be seen as a constraining sub-condition. On the other hand, if a farmer is not a tenant but only owns plots, then this can be seen as a promoting sub-condition.

Effectiveness of groundwater regulation with a subirrigation system

One sub-condition that stands out to be promoting is the effectiveness of regulation of the groundwater level with a subirrigation system. This also includes that the subirrigation system can pump water into the drains and drain the water when the plot is too wet. This advantage was also quoted by KLIMAP-farmer Hendrikus Spoelman:

"But the beautiful thing about this system is when it's wet, it drains the water away. If it is dry, you supply water and that is exactly what appealed to me. You can go two ways with it."

Also, KLIMAP-farmer Hemstede sees the advantages of the two-way working of the subirrigation system:

"You just see with this system that in a wet period, the soil is dry sooner and in a dry period it stays wet much longer, so that is just favourable."

However, it depends, also in combination with the height of the plot in relation to the Vecht, on what works better for each farmer.

For example, KLIMAP farmer Robert Geertman coined that also: *"I use it for both to supply and to drain, only one is more effective than the other."*

Concluding, the overall effectiveness of the groundwater regulation with a subirrigation system is proper. Farmers can drain the water when their plot is too wet and supply water when the plot is too dry. This sub-condition can therefore be seen as promoting for the farmers that have a plot that is too dry or too wet.

4.2.3 Crop-related conditions

Next to soil-related conditions and non-related soil conditions, the condition of 'crops' also has some important sub-conditions which promote or constrain the adoption of the social practice of subirrigation in Stegeren. These two sub-conditions are as follows:

Type of crop

The 'type of crop' is the first sub-condition related to the condition of 'crops'. Throughout the interviews and observations, it appeared that the type of crop is of importance for further adoption of the social practice of subirrigation. Since not every type of crop has the same duration on the plot, for example: grass will be sowed again after approximately 20 years and corn and sugar beets have to be sowed every year. This differentiation in how many times a crop has to sow again results in the difference in root depth between the crops in the soil. Robert Geertman, KLIMAP farmer, also confirmed this during the interview:
"Corn roots do not grow that deep into the soil, because every year they have to be sown again."
Moreover, KLIMAP farmers are not using their subirrigation system on plots where some specific types of crops grow. For example, potatoes, where at one point in growth progress potatoes have to be hilled. By doing this the depth of the root of the potato is considerably high. Therefore, these roots are not able to reach the groundwater, even by using the subirrigation system. This issue was also explained by non-KLIMAP farmer Visscher, who said that he cannot use the subirrigation system on his plots with potatoes because he is not convinced that the subirrigation system can pump up the groundwater level to the height where the roots of the potatoes are. Therefore, most farmers are using their subirrigation system on their plots where grass grows. Other crops are also possible but if the farmer also has a high plot, in combination with a crop where the roots cannot go deep, it is not evident if the subirrigation system can pump up the groundwater that high. This can be seen as a constraining sub-condition.
The sub-condition of crop type is in line with the later-described sub-condition of yield, thus how effective is the subirrigation system in bringing groundwater to the roots of the crops.
Moreover, if the roots of the crop can reach the groundwater, it is also dependent on how high the groundwater is at the base level. For example, KLIMAP farmer

Hemstede has relatively low plots which results in the fact that he does not need deep-rooted crops, he also confirms this during the interview:
"When I see how it works now, I don't need to switch to deep-rooted crops"

Concluding, the type of crop that the farmer wants to harvest each year can be seen as a constraining sub-condition. Because the farmer will not use the subirrigation system on a relatively high plot with crops where the roots do not go deep. This sub-condition can partly be solved by investigating the yield of the subirrigation in combination with the type of the crop and low/high plots.

Quality and weight of the crop
Besides the type of the crop, a second sub-condition, the quality and weight of the crop came to light during the interviews. Different KLIMAP farmers stated that the quality was influenced positively because of the use of subirrigation. This is also in combination with another sub-condition, namely: the effectiveness of groundwater regulation with a subirrigation system. Hendrikus Spoelman also experienced this:
"But those potatoes were so wet, that they did not come out and that is no longer an issue, so that is a sign that the system of subirrigation is working properly [...] and the nutritional values of the corn are also higher. so it (sub-irrigation) has a direct and indirect influence."
Also, non-KLIMAP farmer Bennie Seinen, thinks that the yield, in terms of the weight of the harvest, can be increased by using the system of subirrigation:
"I think the yield can be increased, When you irrigate that water very evenly from the bottom, then that plant will grow much more evenly than if we, so to speak, splash 10 or 15 millimetres of cold water over it. Because then the plant just stands still because the water is too cold. If you could irrigate from below, I think that the yield will increase."
The important difference with a sprinkler system is the regulated growth of a crop because of the regular flow of water, as Bennie Seinen said. However, for growing crops, other factors are also important as Hemstede stated during the interview:
"If the crop can grow at a continuous rate, you will always have better crops. You also always have better nutrients because it contains more nutrients in it, it's that simple. But look for the overall quality of the grass, it depends on more factors and you have to have them all right."
Besides the fact that other factors are influencing the weight and quality of the crop, the subirrigation system does help to increase the overall quality and weight. Therefore this sub-condition can merely be seen as a promoting sub-condition for the adoption of the social practice of subirrigation in Stegeren.

4.2.4 Conditions related to the 'material' element that promote or constrain the adoption of the social practice of subirrigation in Stegeren.

Thus, besides the conditions related to the crop, there are different soil and non-soil-related conditions which promote or constrain the adoption of the social practice of subirrigation in Stegeren. In paragraphs, 4.2.1 till 4.2.3 the promoting and constraining conditions that resulted from the interviews and observations are described as the material element of the social practice of subirrigation in Stegeren. Each condition has its own promoting and constraining sub-conditions.

The promoting and constraining sub-conditions that derived from the soil-related condition were:
-The type of soil and the condition of the soil together with the capillary function and its permeability have a big influence on whether the subirrigation will work at a farmer's plot or not. Therefore the functioning of the subirrigation system can work differently for each farmer. However, in Stegeren most of the soils are sandy, which is not the ideal soil type and does not have the ideal soil condition. This can constrain further adoption of subirrigation in Stegeren.
-To make optimal use of and get the highest yield of the fertilizer that is being used on the plots, the moistening of the fertilizer is necessary. However, this is not possible by using only the subirrigation system which means that farmers still need to use their sprinkling system. This leads to more labour costs and extra investments. It turned out that farmers in Stegeren are not willing to do that. Therefore this sub-condition can be approached as constraining for the material element of this social practice.
-To let the subirrigation system work optimal, the flatness of the ground level is required. Since most farmers in Stegeren do not have a flat ground level, this needs to be flattened first. This process can lead to extra costs, farmers are not always willing to invest in without a subsidy.

Secondly, the promoting and constraining non-related soil conditions are as follows:
-Since each farmer is located differently in height of their plots in relation to the river the Vecht, each farmer is therefore located relatively low or high. This means that farmers have a relatively wet or dry plot. This can both be seen as constraining and promoting since both types of plots are useful for the use of subirrigation systems. The subirrigation system can be used to supply water to dry plots and to drain water from wet plots. However, if the plot is not always too wet or too dry and has the right amount of water, then the subirrigation system is less required.
-One of the crucial sub-conditions to make the subirrigation system work, is the availability of surface water. In Stegeren groundwater cannot be used because of the concentration of iron and manganese in the water. However, not every farmer in Stegeren does have access to surface water and therefore cannot make use of the subirrigation system. Moreover, the availability of surface water also depends on the delivery of this water from the Waterboard Vechtstromen.

At this moment the maximum capacity of surface water is being used in Stegeren, which leads to the consequence that other farmers cannot adopt the subirrigation system. This sub-condition is therefore constraining in two ways in the area of Stegeren. Firstly, if the farmer does not have access to surface water and secondly because there is no 'water demand space' at this moment in Stegeren to make further adoption possible.
-The fact that a farmer is an owner or a tenant of a plot does have a considerable influence on the installation of a potential subirrigation system on that plot. It turned out that farmers are not willing to invest in a subirrigation system if they are renting or exchanging a plot with another farmer. Since renting and exchanging is common in Stegeren, farmers do not have the incentive to install the subirrigation system on that plot. This means that farmers are bound to the plots they already bought. This leads to the consequence that the available plots, to install the subirrigation system on, shrinks and therefore this sub-condition can be seen as constraining the further adoption of this social practice.
-The subirrigation system is a two-way working system, which delivers water and drains water. During this research, it resulted that farmers are pleased with this two-way function and are also content with its effectiveness in doing that.
Therefore this sub-condition can be seen as promoting to make further adoption possible.

At last, the crop-related sub-conditions from the material element were researched on the influence they have on the further adoption of the social practice of subirrigation in Stegeren:

-The type of crop is significant for the proper working of the subirrigation system. This sub-condition is in line with the yield of the subirrigation system since it is not clear how high the subirrigation system can bring up the groundwater level precisely. This also depends on the depths of the roots of the crops. Since grass is rooting deep, most farmers are using the system on plots where grass grows. Other crops, like potatoes, are not suitable when using the subirrigation system. The type of crop can therefore be a constraining sub-condition since the yield of the subirrigation system for every crop is not evident because the yield differs for different types of crops and together with the depths of its roots.
-By using the subirrigation system the quality and weight of the crop increased at the KLIMAP farmers' plots. One of the reasons for this is the regular delivery of water which resulted in the roots of the crops being constantly moistened. This turned out in crops with better quality and weight. For that reason, this sub-condition is promoting further adoption of the social practice of subirrigation in Stegeren.
Nonetheless, it is important to notice that this can differ for each farmer. For example, each farmer is bound to the availability of water and the type of soil, as described earlier these conditions are considered as given. Other constraining sub-conditions such as the flatness of the ground level can be influenced to make the adoption of the social practice of subirrigation still possible.

However, there are some sub-conditions which promote the adoption of the social practice of subirrigation in Stegeren. If the plot of a farmer is placed too low or too high, relative to the river the Vecht, this can promote the farmer to drain the abundance of water or when the land is too dry, the farmer can moisten his plot by using the subirrigation system.
Thus, adoption of the social practice of subirrigation, seen from the material element, is possible. However, some crucial sub-conditions have to be met first, these sub-conditions entail; the availability of surface water and the associated 'water demand space', also the type of crop is important for the working of the subirrigation system. Further, good enough soil type and soil condition are necessary. Then, these (sub)conditions have to be applied on plots where the farmer is the owner of the plot and the farmer himself has to be willing to invest in the subirrigation system if the farmer thinks his plot is too dry or too wet.
A lot of different material (sub)conditions have to be met, to realise the adoption of the social practice of subirrigation in this area. However, since the waterboard Vechtstromen stated that there is no 'water demand space' at this moment, further adoption of this social practice of subirrigation in Stegeren, from a viewpoint of the material element, is at this moment not possible.

4.3 The meaning element of the social practice of subirrigation

This paragraph will describe the promoting and constraining (sub)conditions related to the meaning element of the social practice of subirrigation in Stegeren.
Before the commencement of the interview and observations, the researcher made a clear division between the conditions of the meaning element. This division is made since it became clear, during the literature study, that these three conditions: economic, climatic and the perceived value to the different irrigation systems, are in general important for the meaning element of the social practice of (sub)irrigation. Each condition has different sub-conditions which can be considered as promoting or constraining for further adoption of this social practice. These conditions will be described in paragraphs 4.3.1 to 4.3.3. By using these three main category conditions, a clear answer can be formed to the second sub-question in paragraph 4.3.4.

4.3.1 Economic conditions

After analysing the gathered data from the observations and the interviews with the ten respondents, some important economic sub-conditions related to the meaning element of the social practice of subirrigation became apparent that make further adoption of this social practice possible or can constrain further adoption of this same social practice.

The investment costs of the subirrigation system

During the interviews, the farmers, who have not installed the subirrigation system, said that the investment costs for the subirrigation system were seen as an obstruction for installing the subirrigation system. For example, Bennie Seinen, a non-KLIMAP farmer said the following:

"I think it's quite expensive to have all that drainage laid. Subdrainage you have to count on € 2 per metre."

The same reason was stated by non-KLIMAP farmer Martin Nijkamp: *"I'm actually not willing to make any really big investments in it."*

On the other hand, KLIMAP farmers who did invest in the subirrigation system are content with the investment they made. One example of this is KLIMAP farmer Hendrikus Spoelman:

"I think indeed that the investment in the subirrigation system will pay back later."

Also, KLIMAP farmer Evert Kremer was convinced that the investment will pay back later:

"We also knew that it was going to cost money. But, I do expect that it will return in the longer term. so no more doubts."

Nevertheless, other KLIMAP farmers do think that the investment is too big to install on all plots or in some cases more plots than they have now. This is also expressed by the KLIMAP farmer Maarten Paarhuis:

"You can't put everything in subirrigation. If you want to put 50 hectares in subirrigation, I don't know what the cost will be."

This sub-condition is also in line with the sub-condition of the material element: the availability of surface water. If there is not enough surface water available to use for the subirrigation system, in the first place. Farmers are not willing to invest in the subirrigation system since they still have to make use of their sprinkler system. This fair point was also mentioned by non-KLIMAP farmers, Bennie Seinen en Martin Nijkamp:

"I think that there are a lot of farmers who say, wait a second. If I still have to use a sprinkler installation for that amount of investment money in the subirrigation system, then I will not do it. I won't."

"I have heard some experience of whether it is good or not, but it is not yet the case that everyone is going to install the entire subirrigation system. That is again due to the costs you encounter and those farmers, Kremer, Hemstede and Geertman, they all irrigate to. They also all say that it does make a difference but you can't replace the sprinkler irrigation."

During the interviews, it also became apparent that the non-KLIMAP farmers think that the investment costs are too high because there is no clear cost-benefit analysis of the subirrigation system or a clear yield for this system in comparison with a sprinkler system. This issue automatically introduces the second economic sub-condition.

The cost-benefit analysis/ yield of the subirrigation system

A pivotal sub-condition for the adoption of the social practice of subirrigation is the cost-benefit of the subirrigation system and the yield of the subirrigation system in comparison with a sprinkler system. During the interviews and observations, it was clear that one of the main reasons non-KLIMAP farmers were not willing to adopt the social practice of subirrigation is the absence of an 'economic picture' of the effectiveness of the subirrigation system in comparison with the sprinkler system. During the observations and conversations with non-KLIMAP farmer Visscher, the farmer stated this also:

"Why invest in a system for the next 10-20 years, if the yield of the system on your plot is not even clear yet?"

The yield and the cost-benefit of the subirrigation system fall apart into two categories:

1. The first category entails the costs of the subirrigation system in comparison with the sprinkler system and how much money is saved.

This condition for example is one of the reasons that non-KLIMAP farmer Han Schukkert, is constrained from installing the subirrigation system:

"I do see a return, but I still find it difficult to compare the economic return."

Also, Martin Nijkamp, a non-KLIMAP farmer, wants to know when the investment in the subirrigation system is earned back.

"If you make such a large investment then you must have earned back at some point, I don't know how long something like this system will last and how you will have to maintain it. If you haven't earned it back yet, I think. Then you better invest the money elsewhere."

2. This category is focused on how much water from the subirrigation system can indeed reach the roots of the crops from below the surface. In other words, it is not clear enough how much water from the subirrigation system ends up at the roots in comparison with the sprinkler system. Farmers know that, when using a sprinkler system, the water will reach the crop and its roots. However, when using the subirrigation system no clarity can be given on that.

Both KLIMAP and non-KLIMAP farmers do encounter this problem. This problem did also appear during the interview with KLIMAP farmer Robert Geertman:

"With a sprinkler system, you bring water at the roots and with those drains (subirrigation) it must first raise the groundwater to the roots of the crops and that is already a question if that is possible."

The yield on how much water the subirrigation system can bring to the crops is thus not clear, meanwhile for the sprinkler system this is explicit. There is a lack of research/evidence on how the costs are related to how much water can be brought to the roots of the crops and thus how beneficial the subirrigation system is in comparison with the sprinkler installation.
This lack of evidence is also experienced by KLIMAP-farmer Evert Kremer:
"But I am curious about what the yield of the water is in the end. If you are only replenishing your groundwater from the ditch and you only use 5 or 10% for grass growth. Yes, then the yield of the sprinkler system is maybe even better."

To conclude, the adoption of subirrigation can be constrained by the presence of a 'black box' that represents the yield and the cost-benefit analysis of the subirrigation system. Non-KLIMAP farmers are hindered by the fact that there is no clear yield picture in comparison with the famous sprinkler irrigation. As earlier described, this yield and cost-benefit picture are related to how much water can be brought to the roots of crops and how much time it takes to earn back the subirrigation system. Therefore, the black box of yield and cost-benefit can be approached as a constraining sub-condition for the adoption of the social practice of subirrigation in Stegeren.

The influence of a possible subsidy
To lower the investment costs and make the adoption of the social practice of subirrigation more attractive, farmers associated with the KLIMAP project received a subsidy for the instalment of the subirrigation system. Such a subsidy convinced these farmers in some way to install the subirrigation system. Different KLIMAP farmers stated during the interviews that the subsidy helped to convince them. One example is KLIMAP farmer Evert Kremer, when the researcher asked if he would participate in this pilot study without a subsidy the farmer gave the following answer:
"I think less quickly, especially because there were extra costs that were not compensated in that case."
KLIMAP farmer Robert Geertman said the following on subsidies:
"You also have to finance a large part yourself and we opted for a plot because otherwise the investment (without a subsidy) would be too big for me."
This would mean that this farmer probably would not have joined the subirrigation pilot study in Stegeren if a subsidy was not available.

Next to farmers who are related to the KLIMAP pilot study, farmers who are not participating in the pilot study are attracted by the subsidy and would install subirrigation earlier if a subsidy was available.
This was also the case for non-KLIMAP farmer Martin Nijkamp, who considered subirrigation because of the subsidy:
"And there was such a possibility to get a subsidy and then I went to investigate the possibilities of it (subirrigation system)."

Next to this farmer, Bennie Seinen, another non-KLIMAP farmer argumented this about subsidy:
"If they would grant subsidy on this, yes, then the step would of course be a bit easier to say: we are going to try a bit of subirrigation here."

To conclude, subsidies can be seen as a promoting condition of the material element of the social practice of subirrigation. Subsidies make the subirrigation system for the non-KLIMAP farmer more attractive in the first place.
Secondly, the subsidies helped the KLIMAP farmers to ease their decision to install the subirrigation system on their plots. On the other hand, an advantage of the subirrigation system is that when the system is placed, it is not expensive to keep the system running in comparison with the sprinkler system. How this unfolds is explained with the next sub-condition.

Labour costs and fuel costs
As stated earlier, the investment costs are seen as a constraining sub-condition for the social practice of subirrigation, this could partly be solved with the promoting sub-condition of a possible subsidy.
On the other hand, sprinkler systems are also viewed as relatively expensive by the farmers. The costs of the sprinkler systems consist of mainly the labour costs and costs made because of the used fuel.
KLIMAP and non-KLIMAP farmers are also experiencing costs due to the use of sprinkler systems, for example, KLIMAP farmer Robert Geertman:
"That is a real advantage (of subirrigation) if you don't have to irrigate. And, that makes a huge difference in costs and time."
In addition, non-KLIMAP farmers, such as Bennie Seinen and Visscher, also mentioned this point during the interview and conversations. Bennie Seinen also cited that the making of a spring for groundwater can also be quite expensive:
"And then you have to do it (subirrigation) for the lesser work,[...] Don't forget, making a little spring is also around 2700-2800 euros and if you are a bit lucky, if you should not have to drill too deep, but if you have to drill deeper you will lose 3000. Look, you have to count on that too."

These labour and fuel costs can be seen as a promoting sub-condition for the adoption of subirrigation in Stegeren since these costs have to be made every time the farmer uses the sprinkler installation. Moreover, at this time, fuel costs are also rising quite exceptionally which makes the use of the sprinkling system also less attractive. Therefore the sub-condition of labour costs and fuel costs related to the use of a sprinkler installation can be seen as a promoting sub-condition for further adoption of the social practice of subirrigation in Stegeren.

Incentives to make subirrigation attractive
As described earlier, subsidies can help to promote the adoption of the social practice of subirrigation in Stegeren. Next to subsidies, other (economic) incentives can help to make the subirrigation system more attractive. KLIMAP farmer Evert Kremer proposed during the interview the following economic incentive to promote the adoption of subirrigation:
Since most dairy farmers in the area of Stegeren are Cono farmers, the company that makes Beemster cheese. This Cono cooperation has a sustainability program, called Caring Dairy where farmers are rewarded if they increase the sustainability, biodiversity and animal welfare on their farm. This program consists of 18 indicators and for each achieved indicator the farmer gets €0,05 extra for every 100 litres of milk. However, as Evert Kremer pointed out during the interviews, Cono farmers are not getting rewarded to make their way of irrigation more sustainable/climate adaptive and thus saving water. If they (the Cono cooperation) would do this, subirrigation would be more attractive for other farmers to implement on their plot, he said. Now, farmers are not getting rewarded for the implementation of more sustainable/climate adaptive measures on their plots. Next to increasing the attractiveness of subirrigation, the investment costs will be earned back more quickly. If this economic incentive should be implemented at the Cono corporation, then this could be approached as a promoting sub-condition for the social practice of subirrigation in Stegeren.

Other farmers also mentioned other incentives to promote the adoption of the social practice of subirrigation in Stegeren. One of these incentives is also mentioned by Evert Kremer, who said that it is necessary to make farmers more familiar with subirrigation by increasing the publicity about the subirrigation system:
"And if you do have good experiences, that is often what works best for farmers. That sort of thing in the articles in trade journals and during open days."

Also, the right timing to spread information about the subirrigation system could help:
"If you want to organize the next meeting about subirrigation you have to do it after it has been dry for 5 weeks. Then you attract more people, instead of it's been raining all summer."

Thus, economic incentives, like the Caring Dairy program and publishing good experiences of other farmers in agriculture journals and meetings with the right timing can be approached as a promoting sub-condition for the social practice of subirrigation in Stegeren.

Moment of installation of the subirrigation system
Some KLIMAP farmers also stated that the moment of the installation of the subirrigation system is important. Like KLIMAP farmer Robert Geertman:
"The project runs in a certain period, say 4 years. But if you want to install subirrigation, it would be nice if you split (tear up) the grassland. Destroy it and then you put in that subirrigation and that you then prepare your land again and then you

sow new grass and that you can enjoy for years to come[..] Luckily I already wanted to tear up my grassland since it was 20 years old" [..]. *In that way, you are time-bound when you want to install the system on your plot."*
The farmers said that the best time to install the system is if you want to renew your grassland and just before the sowing of your grassland. This point was also mentioned by Evert Kremer, KLIMAP farmer:
"Yes, the right moment to lay the drainage is with the new sowing, then you can calve nicely again and you can make it nice and flat. [...] However, I just reseeded all the house plots here. So well, then you also incur certain costs."

The moment of installation can therefore be understood as a somewhat constraining sub-condition for some farmers. Since the farmer does want to install the drainage at the moment before seeding and on a relatively old plot. This means that a farmer can be time-bound and place-bound for the installation of the subirrigation.

Income (in)security
During the interviews and observations, it became clear that the general economic reasoning for the farmers is important to install the subirrigation system. In this research, economic reasoning is described as the sub-condition of income (in)security. KLIMAP and non-KLIMAP farmers expressed the importance of having a high yield and having an associated proper income. This importance of income and economy is also expressed by KLIMAP farmer, Hendrikus Spoelman:
"As a farmer, you are economically active every day, otherwise you are not a farmer. Yes, it is a bit of a hobby, but economics is at the top actually. [...] It is one of the reasons I installed the subirrigation system."
And KLIMAP farmer, Maarten Paarhuis, answered on the question if economic reasons are the most important, the following:
" Yes, we are a company, we're not a charity."
Next to KLIMAP farmers, non-KLIMAP farmer Han Schukkert underscores the economic reasons:
"In the end, it's all about the economic aspect. We can't get around that."

Thus, for both groups of farmers, income security is important and for some KLIMAP farmers the reason for installing the subirrigation system. However, it depends separately on each farmer, how important this sub-condition is. During the interviews the researcher also asked how important climatic (sub)conditions are, this will be described in subparagraph 4.3.2.

4.3.2 Climatic conditions

After describing the promoting and constraining economic sub-conditions, during the interviews the researcher also asked how important climatic conditions are, these sub-conditions will be described in this paragraph.

Impact of climate change on the farmer

The first sub-condition is the impact of climate change on the farmer. Thus, to what extent does the farmer want to install the subirrigation system or did install the subirrigation system on their plots because of the impact of climate change.
After the interviews and observations, it became apparent that the climatic sub-conditions and their consequences, in general, do not really influence the farmers' choice to install the subirrigation system and that climatic sub-conditions do not automatically play a role in choosing the subirrigation system. Also, non-KLIMAP farmer, Martin Nijkamp, stated that he doesn't know what the consequences of climate change will be: *"But I don't know what will happen with climate change. You will get even more extreme rain showers, maybe it will get wetter. And that is also a point that also counts [...] And if everything dries up, then that also costs money and will cost more, but that doesn't happen every year. Last year, that was fine and you didn't need the system."*

For other farmers, the impact of climate change automatically plays a role but is not the main reason for the adoption of the subirrigation system. For example, Hendrikus Spoelman, KLIMAP farmer:
"You're working on a wet plot and a dry plot and climate naturally influence that, but the goal was to drain water when it got too wet and pump up water when it got too dry. And that automatically has to do with the climate."
Why the impact of climate change does not have a direct influence on the farmers' adoption of subirrigation, can partly be explained by the second sub-condition.

Attitude to climate change (historical sub-condition)

This sub-condition explains how farmers perceive climate change. Since a lot of farmers are making a comparison with the past, this sub-condition is called a historical sub-condition. During the observations and conversations, different KLIMAP and non-KLIMAP farmers explained their views on climate change.
It became clear that farmers are aware of climate change but the severity of the present and future status of climate change is a bit exorbitant.
This also applies to KLIMAP farmer, Hemstede:
"Yes of course the climate is important, I have been involved in it for years. 30 years ago and 40 years ago, it was not different. Only now they do make the problem much bigger than it was then. It's that simple."

Also non-KLIMAP farmer Visscher is conscious of climate change however he also said the following:
"In the past we also had periods where it was very wet or dry, then we also recovered from these periods. However, I realise that climate change is getting more severe but not at the pace that I want to change my way of irrigation."

On the other hand, other farmers do see that climate change is getting more severe and therefore these farmers are content that they have installed the subirrigation system. However, climate change is not the main reason why the farmer adopted subirrigation. This reasoning is also the case by KLIMAP farmer, Evert Kremer:
"If that weather really gets more and more extreme, what the weather experts predict. Yes, that is a bit more difficult to deal with as a farmer. It is often all or nothing and I have had that feeling in recent years that either you have a long dry period or there is so much rain and a short time, then it's a bit easier if you can anticipate that better with this system."

To conclude, during the observations and interviews it became clear that the attitude to climate change from a farmer's perspective, is in some way a bit conservative. The main reason for this attitude is that the farmers in Stegeren are dealing with climate change for a long time now and were always be able to recover from the consequences of it. Therefore, their attitude to climate change and this sub-condition can be approached as a bit constraining in that sense. To which extent this sub-condition can be seen as constraining depends on each separate farmer. Since there are non-KLIMAP farmers in Stegeren who are aware of the severity of climate change and its consequences.

Nature-inclusive agriculture
This sub-condition is in line with the earlier described sub-condition referring to the impact of climate change. Nature-inclusive agriculture strives for a more sustainable way of agriculture with increased biodiversity. Jan Willem Hekman, water level manager, explained during the interview that the board of the waterboard Vechtstromen can be described as 'green' which means that the waterboard Vechtstromen strives for more focus on nature and nature-inclusive agriculture in the area of Stegeren.
According to Jan Willem Hekman, this will lead to the following consequence:
"We currently have a very green board, so they also have a lot of nature in mind. So yes, I'm not saying that agriculture is being pushed aside altogether. Absolutely not, because that's not possible, they still have to earn their income. But we see that the water has to be distributed more and more, also towards nature.[...] I think it is possible in some places, but there are also places where that is simply not possible where the income cannot be earned with nature-inclusive agriculture."

In Stegeren most farmers stress the fact that a farmer has to earn their money with respect to nature. For example, KLIMAP farmer Maarten Paarhuis and Robert Geertman quoted the following:
"A farmer is an entrepreneur, but yes, you also take care of nature"
"In addition, you also work in nature. In the environment, you have to be good for nature and also be good for the environment."

However, some other farmers think that nature-inclusive agriculture is not possible at all. For example, KLIMAP farmer Hemstede:
"The phenomenon of nature-inclusiveness is the new one, that's what people would like. Yes, well I'm quite busy with that too [...] but there is simply no revenue model in it. You can think of all kinds of things, but if there is no revenue model, then nothing will work for both."

Thus, because of a more nature-inclusive focus in Stegeren, the available surface water also will be divided more to nature in the future, where normally this water could be used for the subirrigation systems. Therefore, more nature-inclusive agriculture can constrain the further adoption of the social practice of subirrigation. Although most farmers are aware of the fact that nature is important and that they have to work with nature instead of against nature.

The relation between the farmer and the waterboard Vechtstromen
In the interviews and during the observations it became evident that a good relationship with the waterboard Vechtstromen is crucial for making the adoption of the social practice of subirrigation possible. This is also confirmed by KLIMAP farmer Robert Geertman:
"That is (the relation) I would almost say, crucial. If the waterboard does not agree with what you are going to do with your subirrigation, then you get a lot of resentment, because then you start pumping it and then the waterboard says, for example, it has all dried up here, you are pumping all the water to your groundwater. You must have a good relationship with the water board and the person who ensures that the water gets to the place where it is needed."

In the area of Stegeren, a good relationship between the farmers and the waterboard Vechtstromen is present. This can be confirmed by the waterboard itself as well as by other farmers. Jan Willem Hekman, water level manager said the following about the relationship between them:
"The relationship between the waterboard and the farmer is good in this area."
Also, the farmers are confirming this, for example, KLIMAP farmer Robert Geertman:
"Yes, I also have good ties with the water board in this area."

Thus, a good relationship between the waterboard and farmers is crucial, since the waterboard is the 'person' that has to deliver the surface water to keep the subirrigation system running. Next to the role of the deliverer of surface water, the waterboard also has to promote the adoption of subirrigation in the area of Stegeren, which is indeed the case according to Jan Willem Hekman.
Therefore, this sub-condition is seen as promoting the adoption of the social practice of subirrigation in the area of Stegeren since the relationship in Stegeren between the waterboard and farmers is considered as good.

Importance of the KLIMAP project for the farmer and the waterboard Vechtstromen

This sub-condition applies to a more general context to make adoption of the social practice of subirrigation possible in Stegeren and other areas than Stegeren. The implementation of subirrigation in Stegeren stems from the pilot study of KLIMAP, during the interviews it became apparent how important the KLIMAP pilot study still is for the farmers, the water level manager and therefore for the area of Stegeren. For that reason, it is important to explain why this is the case. By doing this, it could help future pilot studies related to subirrigation to make the adoption of subirrigation more attractive.
In the interviews, the farmers expressed the importance of the KLIMAP project and particularly the pilot study in Stegeren. They especially expressed their feeling that it would be sad if the pilot study will gradually stop in the near future.
The reason for this is, according to the farmers, the involvement of KLIMAP itself is much less intensive than in the beginning. These worries are also expressed by Hendrikus Spoelman:
"I would like it if it would be more fanatic. Otherwise, it will come to a side path and the light will go out. That would be a pity. If you do it, you have to do it well."
And farmer Evert Kremer said the following on this:
"I think there is more in the project than there is now, if nothing happens, as the past year, I'm afraid it will gradually fade away. I'm afraid of that to happen."
Also, the water level manager, Jan Willem Hekman, of the waterboard stresses the importance of the KLIMAP project:
"I certainly think that is a very good initiative for the future."

Next to the importance of the pilot study itself, farmers explained that they are also learning from the project. Ranging from more knowledge about the use of water (KLIMAP farmer Evert Kremer) to more general information on sustainable agriculture (KLIMAP farmer Robert Geertman).

In conclusion, more attention to this pilot and future pilots of KLIMAP, will help to achieve the most out of those pilot studies about subirrigation. Cause it would be a pity to not achieve the maximum out of a pilot study when it will be initiated or already is initiated, as the pilot study in Stegeren.

4.3.3 Personal values related to the irrigation systems

Besides economic and climate conditions that promote or constrain the adoption of the social practice of subirrigation, the personal values farmers have regarding both the irrigation systems can be approached as constraining or promoting for the adoption of the social practice of subirrigation. As stated earlier, these values do not consist of purely economic or climatic conditions but describe the reasons farmers gave and how they 'feel' regarding both the irrigation systems and why they would use either of the two or both the systems. This condition exists of two sub-conditions:

Personal value regarding the sprinkler system in comparison with the subirrigation system

This sub-condition entails why particular farmers are using the sprinkler system instead of the subirrigation or vice versa. For example, Robert Geertman expected something different from the subirrigation system during the pilot study:

"But I actually hoped that pumping the water into the drains would make it easier and that it would be easier to get it up so that the roots can reach it better. I still use the sprinkler system and I wasn't supposed to do that anymore."

And non-KLIMAP farmer, Martin Nijkamp, is still struggling with the advantages and disadvantages of both the systems to raise the groundwater level:

"Others say it makes a difference((with the groundwater level), I don't have to irrigate anymore, but if it is a lower plot than I have here. Of course, it is always difficult to compare [...] That is the hesitation I have with the subirrigation system."

On the other hand, other farmers do feel more connection with the subirrigation system than the sprinkler system. This is also the case with KLIMAP farmer Hendrikus Spoelman:

"Because the subirrigation is much more useful than normal irrigation, you have a lot more work with that and then some water evaporates too. And now you are going to irrigate from beneath which is actually much better."

Others, like the water level manager of waterboard the Vechtstromen, Jan Willem Hekman, sees the advantages of subirrigation. However, for him it is too early to reach definitive conclusions about the subirrigation system:

"To put everyone right on that level-controlled drainage(subirrigation). I don't know if that's either good or bad. We do use the sprinkler system on many occasions. In principle, it has always worked well. Because now to do something different all at once, real research has to be done first."

To conclude, it is difficult to say if this sub-condition is rather constraining or promoting since each farmer has different values and feelings for both the irrigation systems. However, it is important to still address these values since it can help to express why some farmers are not in favour of the subirrigation system and vice versa which could help to understand and to help further adoption of this social practice.

Personal value related to the subirrigation system

The second sub-condition describes the perceived value that the farmers have or do not have regarding the subirrigation system. KLIMAP farmer Evert Kremer shared his thoughts about how farmers perceive agricultural innovations in general including the subirrigation system and how he thinks about the subirrigation system:

"Maybe that's normal for every group and even more for the group of farmers. When new things and changes are implemented, we first see in which way the cat jumps. But maybe that should change bit by bit now. [...] There is enthusiasm to use the subirrigation system, but that everyone wants to use it en masse, I don't think so."

Non-KLIMAP farmer Han Schukkert had the following feeling about the subirrigation system:

"Look, how I perceive subirrigation at this moment, I see something in it and certainly for in the future. However, it needs to be further developed."

One of the reasons, that the masse of the farmers perceive subirrigation as something too new to invest in, even if this pilot turns out to be successful, was also stated by KLIMAP farmer Maarten Paarhuis:

"There is actually too little information about subirrigation for the large group.[...] and it is still too complex and new."

Thus, despite the pilot study in Stegeren and other implementations of subirrigation in other areas, subirrigation is still perceived as something that there is too little information about for the large group and as something too little research has been done on. This could be a constraining sub-condition to increase further adoption of the social practice of subirrigation in Stegeren.

However, this constraining sub-condition could be solved by providing more information about the subirrigation system and its advantages in comparison with the sprinkler system for the large group of farmers. This information should also include, the earlier described, yield and cost-benefit of the subirrigation system in comparison with using a sprinkler installation.

4.3.5 Conditions related to the 'meaning' element that promote or constrain the adoption of the social practice of subirrigation in Stegeren.

As stated at the beginning of the paragraph, different economic sub-conditions, climatic sub-conditions and personal values to both the irrigation systems can constrain and promote the adoption of the social practice of subirrigation in Stegeren. After analysing the data, it became clear that the economic sub-conditions are more of an influence than the climatic sub-conditions since farmers in Stegeren are more economically orientated than focused on climate when considering the adoption of the system of subirrigation. Climatic sub-conditions do play a role when talking about the adoption of subirrigation but the climate (change) cannot be perceived as the main condition to promote or constrain the adoption of subirrigation from a perspective of the meaning element of the social practice of subirrigation.

Different economic sub-conditions came to light that can constrain further adoption of the social practice of subirrigation in Stegeren. These constraining economic sub-conditions are:

-The relatively high investment costs: farmers are less willing to invest in subirrigation if they still have to use their sprinkling system while the costs of the system are relatively high, especially when you have to install the subirrigation system on many plots.
-Almost together with the high investment costs, is the constraining sub-condition of the lack of a clear yield picture of the subirrigation system in comparison with the sprinkler system. As described earlier, farmers are facing a 'black box' of yield and the cost-benefit of the subirrigation system. Therefore farmers are not willing to invest in the subirrigation system if the yield and cost-benefit analysis of the subirrigation system are lacking.
-The moment of installation of the subirrigation system can constrain its further adoption because the farmer does want to install the subirrigation on the moment before seeding and even more important on a relatively old plot.

On the other hand, also promoting economic sub-conditions were found:
-During the pilot study in Stegeren, farmers received a subsidy to join the pilot study. It became clear that the subsidy was important for the KLIMAP farmers to join the pilot. Also, non-KLIMAP farmers explained that a possible subsidy could work in a promoting way for the adoption of subirrigation.

-The high labour and fuel costs of the sprinkler systems are one of the main promoting sub-conditions for further adoption of subirrigation. As both of the farmers' groups explained, high labour and fuel costs are a big disadvantage for the use of sprinkler systems. Therefore, to reduce these costs, the subirrigation system could be appealing and therefore can this sub-condition be seen as promoting.

-Next to subsidies, other (economic) incentives could be appealing for further adoption of subirrigation. For example: to include climate-adaptive irrigation in the Caring Dairy program or the sharing of good experiences with the subirrigation system by other farmers.

Also, climatic sub-conditions can constrain further adoption, the constraining climatic sub-conditions that were found during the research are:

-The impact of climate change: As stated in the beginning, the impact of climate change is for most of the farmers too little to really consider adoption of subirrigation because economic sub-conditions are more important. Why this is the case is explained by the second constraining sub-condition.

-The attitude to climate change from a farmer's perspective is a bit conservative. Since the farmers are dealing with climate change and therefore dry periods and wet periods for a long time and were always able to recover from the consequences, climate change does not encourage farmers to install the subirrigation system. However, farmers are aware that the climate is changing but do not agree with its consequences and severity of it.

-In the interviews, farmers expressed the fact that a farmer has to earn their money with respect to nature. This nature-inclusive agriculture is also one of the targets of the 'green' board of waterboard the Vechtstromen strives for. However, this means that the availability of surface water can be less in the future for the subirrigation systems which constrain further adoption of the subirrigation system in Stegeren.

-Since the waterboard Vechtstromen delivers the surface water, a good relationship between the farmers and the waterboard Vechtstromen is necessary. Luckily, in Stegeren a good relationship exists. This promotes further adoption of subirrigation, even more, the waterboard Vechtstromen also promotes the instalment of the subirrigation system.

-Farmers expressed the importance of the pilot study in Stegeren and that, unfortunately, KLIMAP is not striving for its maximum potential of it. Striving for the maximum potential could produce better insights/results. Moreover, farmers do learn from the pilot as earlier expressed in this paragraph. It is not constraining or promoting in that sense, however, it is an important sub-condition that came to light during this research.

The personal values a farmer has for both the irrigation systems can differ for each farmer. Therefore, it is difficult to state if this sub-condition is constraining or promoting further adoption of the subirrigation system in general. Despite that, it is important to express those values to both the systems which can help the research why subirrigation or the sprinkler system is in favour in Stegeren and other areas.

However, during the interviews, it became clear that there is too little information about subirrigation for the larger group of farmers. This leads to situations where the subirrigation system is perceived as too complex or too new. Also, the missing information about yield and cost/benefit plays a big role. Therefore, this personal value of the missing information can be perceived as a constraining sub-condition.

To conclude, economic sub-conditions are playing a more important role in the meaning element of the social practice of subirrigation than the climatic conditions. However, some climatic sub-conditions do have a constraining or promoting influence on the further adoption of the social practice of subirrigation. Most of the economic and climatic constraining sub-conditions could be fixed quite easily which can contribute to easier adoption of the social practice of subirrigation.

Besides the economic and climatic sub-conditions, the personal value that farmers have differs for each separate farmer. However, these different personal values are important to better understand what promotes and constrains the adoption of the social practice of subirrigation in Stegeren.

4.4 The competence element of the social practice of subirrigation

The third and last element of the social practice of subirrigation in Stegeren, is the competence element. This element is divided into two conditions, each condition has separate sub-conditions which will be explained in paragraphs 4.4.1 and 4.4.2. After explaining how the conditions and sub-conditions can have a promoting or constraining influence on the further adoption of subirrigation, the third sub-question can be answered.

4.4.1 Usability of the system

The first condition that is of influence, deriving from the competence element, on the adoption of the social practice of subirrigation, is the condition that is called: the usability of the system. This condition describes the overall usability of the subirrigation system.

Filters of the subirrigation system

The first sub-condition describes the filters of the subirrigation system which are necessary for the suction of the water that is in the ditches and the filtering of this same water. The filtering of the water is necessary since it prevents the drains from possible congestion(s). To have optimal water flow from the ditches into the drains, the filters have to be cleaned frequently. However, during the interviews and observations, it became clear that the frequency and more important the difficulty to clean the filters can be experienced as burdensome by a relatively big part of the KLIMAP farmers group. KLIMAP farmer Evert Kremer answered the following to the question if the system has easy usability:

"Well, no, I would say not quite yet, you have to clean the filters often, I really have to put on the swimming trunks and go into the ditch to do that, so we have indicated that it should also be easier to do the cleaning."

Also, KLIMAP farmer Hemstede was complaining about the cleaning of the filters of the subirrigation system:

"*You have to clean the filters every time, something else has to be thought of to solve that. But on a winter day, I can easily reach it, however before you know it, the water is already in it (the ditches) again."*

KLIMAP farmer Robert Geertman questioned if it is not possible to have another system to prevent the cleaning of the filters since the cleaning is also time-consuming:

"*So there should actually be a system where you don't have to clean the filter[...] if I have to clean the filter every day, I am not going to do that."*

Thus, the frequent cleaning of the filters to keep the system running and the trouble the farmers have to do that can be seen as a constraining sub-condition. To make further adoption easier in the area of Stegeren, farmers like to see an alternative (easier and less frequent) manner of cleaning the filters of the subirrigation system.

Technical malfunctions and technical back-up

This sub-condition describes how accessible the system is, from a technical perspective, and what farmers will do if technical malfunctions occur. Overall, the KLIMAP farmers do not see the subirrigation system as a very technical system, which increases the accessibility and usability of the subirrigation system.
KLIMAP farmer Hemstede also shared this point of view:
"However, such a high grade of technology is not in the system,[...] it is a simple system from a technical viewpoint."
However, if technical malfunctions occur, most of the KLIMAP farmers have to rely on Gé from the KLIMAP project to fix those technical malfunctions. Also, KLIMAP farmer Hendrikus Spoelman relies on Gé if technical malfunctions occur:
"If there is a technical malfunction, I will call or WhatsApp Gé and he will come and fix it for me."

In the pilot study itself, the technical back-up of Gé can be seen as a promoting sub-condition. Because Gé keeps the subirrigation system and therefore the pilot study running. On the other hand, farmers outside the pilot study who adopt the subirrigation system, cannot rely on a technical back-up.
This point was also made by KLIMAP farmer, Evert Kremer:
"Now it is still no problem because it falls under the KLIMAP project and then you call Gé and then a solution will often be found, but if it is really implemented on a large scale, then I think it should be better."
During the interviews, the farmers were asked how they would act if a serious technical malfunction occurs if they were not part of the pilot study. Most of the time the farmers would have to call for an installer or another person who could fix the technical malfunction. Also, KLIMAP farmer Robert Geertman said this:
"That's the point. If I can't fix it by myself, I think I should call an installer anyway, to check the system if it doesn't work."
This would cost the farmers extra money and time. More importantly, the subirrigation system does not work until the system is fixed by someone else. Therefore, the subirrigation system has to be as technically simple and trustworthy as possible. Something that KLIMAP farmer, Maarten Paarhuis, is also stating:
"The system has to be technically simple and trustworthy of course."

To conclude, during the pilot study the technical malfunctions can be fixed by using the technical back-up of Gé, which can be considered as a promoting sub-condition. However, if other farmers, outside the pilot study, adopt the subirrigation system, they cannot rely on a technical back-up if the technical malfunction is too serious to be fixed by the farmer himself. This can be seen as a constraining sub-condition since an

external installer will also cost the farmer extra money. During the interviews, the farmers stated that an instruction manual (provided during the installation of the system) could help to fix technical malfunctions by themselves instead of an installer. Nevertheless, those instruction manuals were not provided at the beginning of the pilot study.

Maintenance and independent use of the subirrigation system

Throughout the interviews and observations the KLIMAP farmers were also asked if the farmers thought that they could run the subirrigation system independently. The farmers stated that despite the occurrence of technical defects, which sometimes occur, and the cleaning of the filters, the farmers can run the system on their own. KLIMAP farmer Robert Geertman confirmed this during the interview:
"Yes, that's not difficult at all(to run the system). It is a simple system but with some inconveniences such as that filter."

Also, KLIMAP farmer Evert Kremer stated he can run the subirrigation system independently if no technical defects occur:
"Yes, in principle if the system is running it is no problem, but if there are really technical defects then I don't know if I can get it running again or not."

Thus, despite the (possible) occurrence of technical defects, farmers can run the subirrigation system independently, when the subirrigation system is working. This sub-condition can then be seen as promoting since farmers do not have to rely on an external person or company when the system is working.

4.4.2 Skills to operate the subirrigation system

The second and last condition of the competence element of the social practice of subirrigation in Stegeren, consists of the skills to operate the subirrigation system. This condition falls apart in the following three sub-conditions:

Easy to operate the subirrigation system

The first sub-condition falls together with the sub-condition on the independent use of the subirrigation system. As described earlier, KLIMAP farmers are capable of using the subirrigation system independently, unless a technical defect occurs. Because of the independent use of the subirrigation system by the farmers, it is assumed that the subirrigation system is also easy to operate in practice.
KLIMAP farmer Robert Geertman confirmed this during the interview:
"The system itself is very simple. It has been constructed as simply as possible to make it easier for farmers to work with, and it is also easy to work with the solar panels and the pumps. Thus, the system itself is very easy."

KLIMAP farmer Hendrikus Spoelman also thinks that the subirrigation system is easy to operate despite the cleaning of the filters:
"You can easily handle it, you don't have much work with it, you just have to make sure that the filters that are in the water stay clean, so to speak. that they won't clog with offspring and with all kinds of junk."

The KLIMAP farmers are experiencing the subirrigation system as easy to use, which is in line with the promoting sub-condition of the independent use of the subirrigation system. On the other hand, this independent and easy use of the system only applies if no technical defects occur. At last, the sub-condition of the cleaning of the filters of the subirrigation system can affect the ease of use of the system since most farmers are complaining about the filters.

Need for the acquirement of new skills and knowledge and already existing knowledge of the subirrigation system
This sub-condition is focusing on the new skills and knowledge farmers have to assimilate for using the subirrigation system. After the interviews, it turned out that no new significant skills and knowledge were required to operate the subirrigation system. KLIMAP farmer Hemstede answered that it is a simple system that does not require the learning of new skills and knowledge.
KLIMAP farmer Hendrikus Spoelman said the following if the learning of new skills and knowledge is necessary:
"The system works for itself and speaks for itself[...] You don't need a lot of skills and knowledge, it is very simple."

However, farmers could learn new skills to fix technical defects which makes them less dependent on the use of their subirrigation system. Despite learning how to fix technical defects, the learning of new significant skills and knowledge is not required to work with the subirrigation system, therefore this sub-condition can be considered as promoting.

The assistance of KLIMAP to the farmer in this pilot study
As stated earlier, the KLIMAP farmers in this pilot study can count on the technical back-up of KLIMAP when technical defects occur. However, the overall assistance of KLIMAP varies from farmer to farmer.
Evert Kremer said the following regarding the assistance of KLIMAP:
"We have never really had a good explanation and a good manual."

On the other hand, Robert Geertman said the assistance is proper:
"Yes, I think that we are well guided[...] because we have a meeting every year where we are kept informed of what they measure.[...] We have an app where we can communicate with those who are involved in it and then you can ask questions if it is necessary, that is well arranged."

KLIMAP farmer Hemstede is also satisfied with the assistance he has from KLIMAP: *"In itself yes, we had several information evenings and we still have once or twice a year a meeting to exchange information."*

It differs for each farmer how they conceive the assistance of KLIMAP and how much assistance they get from KLIMAP. Technical back-up is always there, however, some farmers, like Evert Kremer, would like to see more assistance than there is now. This sub-condition is not constraining or promoting further upscaling of subirrigation. However, like the sub-condition of the importance of the KLIMAP project for farmers, it is necessary to appoint. The reason for this is that better assistance in this pilot study, and in general, in all pilot studies, will help to receive better results from those pilot studies. Related to this pilot study, better assistance will result in more and better information to make further adoption of the subirrigation system possible.

4.4.3 Conditions related to the 'competence' element that promote or constrain the adoption of the social practice of subirrigation in Stegeren.

As narrated in this paragraph, different constraining and promoting (sub)conditions, deriving from the competence element, are present which are related to the adoption of the social practice of subirrigation in Stegeren. This element was divided into two main conditions: the usability of the subirrigation system and the skills to operate the subirrigation system. The found promoting and constraining sub-conditions of the first condition related to this element are as follows:

-To begin with, the farmers are experiencing the filters of the subirrigation system as a constraining sub-condition. These filters have to be cleaned often, which is the first point of criticism of the farmers. Moreover, farmers are not content with how the filters have to be cleaned, for most of the farmers the cleaning of the filters is paired with too much effort. To make further adoption of subirrigation in Stegeren possible, farmers suggest another filter system then there is now. The farmers like to see a new filter system that can be cleaned more easily and requires less frequent cleaning.

-Secondly, the subirrigation system is not experienced as a system that is technically difficult to understand, which can be understood as a promoting sub-condition for the adoption of this social practice in Stegeren. However, some farmers are experiencing technical malfunctions they cannot fix, therefore they have their technical back-up from the KLIMAP project. New farmers, outside this pilot study, that adopt the subirrigation system do not have access to this technical back-up. For serious technical malfunctions, they have to switch to an installer which can cost extra money. Therefore, this sub-condition can be seen as promoting in the pilot study itself and can be seen as constraining outside the pilot study since farmers are not technically skilled enough to fix the technical malfunctions by themselves.

-Because these technical malfunctions occur on a rare basis, farmers are capable of using the subirrigation system independently since farmers do not have to rely on an external person when the subirrigation system is working. Therefore the independent use of the subirrigation system can be seen as a promoting sub-condition for further adoption of the social practice of subirrigation.
Next to the usability of the system, the condition of 'skills to operate the subirrigation system' is also of importance for the adoption of this social practice. It turned out that this condition and its sub-conditions mainly have a promoting function.

-One of these reasons that farmers can run the subirrigation system independently is that the system is easy to operate. Farmers are experiencing the subirrigation system as easy to use, with the prerequisite that no technical errors occur. This sub-condition can therefore be seen as promoting further adoption of the subirrigation system. However, to increase the ease of use of the subirrigation system, the filters have to be altered in some way so that it is easier to clean them and in a less frequent way.

-What also makes it easy to operate the system is that no new significant skills and knowledge were required to operate the subirrigation system. However, new skills and knowledge could be learned, with help from KLIMAP or without, to understand the subirrigation system better and fix technical errors by themselves instead of relying on the technical back-up. Thus, this sub-condition is promoting the adoption of the social practice of subirrigation, however, it could be even more promoting if farmers obtain the knowledge and skills to fix technical errors by themselves.

-As stated earlier in the paragraph, the perceived assistance of KLIMAP in this pilot project cannot be seen as a promoting or constraining sub-condition for further adoption in the first place. Nonetheless, the experience of the farmers regarding the assistance of KLIMAP, differs for each farmer. In general, good assistance is necessary for this pilot study and other pilot studies to receive the maximum results out of these pilot studies. This could help to gain more information on future adoptions of different pilot studies.

To conclude, the competence element of the social practice of subirrigation in Stegeren has, in general, mostly promoting sub-conditions. No new skills and knowledge are necessary to operate the subirrigation system which results in independent and easy use of the subirrigation system.
On the other hand, 'the filters of the subirrigation system' is a sub-condition which constrains the farmers at this moment, these filters have to be adapted for the future subirrigation systems. At last, farmers in this pilot study are not constrained by the technical errors since they have a technical back-up. Nonetheless, to make future adoptions possible, a solution has to be found for farmers to deal with the occurrence of these technical errors.

4.5 How do the promoting and constraining conditions, related to the social practice of subirrigation in Stegeren, contribute to developing a scaling strategy for this social practice?

After formulating an answer to the first three sub-questions, the fourth and last sub-question can be answered. This sub-question is more focused on how the obtained knowledge about the promoting and constraining conditions of the social practice of subirrigation can help to develop a scaling strategy for this same social practice. The knowledge about both the promoting and constraining conditions is helpful, to develop a scaling strategy for this practice in different ways.

As stated earlier in research, the scaling of innovations from the pilot phase to a broader area is much harder than it seems to be. In this research, the innovation was the social practice of subirrigation. During this research, the underlying reasons that can help or hinder the scaling of subirrigation were researched. These reasons were approached as promoting and constraining (sub)conditions and further split out into the three elements of where a social practice consists of.

By dividing the social practice of subirrigation into the three elements, it became clear what can constrain or promote further adoption of this same social practice. For example, conditions should not be approached separately but are always intertwined with other (sub)conditions and conditions can be influenced by more than one other (sub)conditions.
The availability of water, for example, is one crucial promoting and constraining sub-condition that was researched. However, the availability of water for a farmer does not only depend on the access to surface water at the plots by ditches, it also depends on the division of surface water between agriculture and the increasing importance of nature in Stegeren.
Thus, the first ‘lesson’ that was learnt for scaling this social practice in Stegeren, is that sub-conditions are intertwined with each other and also influence, promote and constrain, each other and more importantly, which (sub)conditions influence other (sub)conditions in a promoting or constraining way.
Before solving one constraining (sub)condition to make further adoption possible, other (sub)conditions that influence this (sub)condition have to be researched first. By doing this, scaling of the subirrigation system to a larger area can be done more easily.

Moreover, by investigating several (sub)conditions from the three elements, it became clear that some conditions are more important than others, despite their influence on each other. For example, in this research, the earlier mentioned availability of surface water is important, but also the yield and cost-benefit of the subirrigation system are important for farmers to know. By trying to tackle the more important constraining sub-conditions first, adoption of the social practice of subirrigation in Stegeren could become more attainable. This research showed which (sub)conditions are more important related to the subirrigation system and therefore helped to develop a scaling

strategy for this social practice.
In line with this reasoning, further scaling of the subirrigation system in Stegeren can be constrained if some crucial (sub)conditions are not met in the first place.
The availability of surface water, soil type and soil condition, for example, are sub-conditions that are crucial to be researched in an area, to know if the implementation of the subirrigation system in this area is generally possible and therefore if further scaling is attainable. This research showed that if not the right type of soil is present together with not having enough availability of surface water, it can constrain further scaling of the subirrigation system. This research explicated what crucial (sub)conditions have to be met to make further scaling possible and therefore contributed to developing a scaling strategy.

Another lesson that can be learned from this research to make further scaling of the subirrigation system possible, is to create more publicity for the use of a subirrigation system and at the same time emphasise the advantages of the subirrigation system in relation to a sprinkler system. Since this research showed that the general group of farmers does not have enough knowledge to make a considered choice to adopt the subirrigation system at this moment. By creating more publicity and providing more information about the subirrigation system to the farmers, the subirrigation system will be more common which can help to ease the process of adoption on a bigger scale and thus improve the scaling process.

Furthermore, it became clear that economic conditions do have a big influence on the adoption of the subirrigation system. It is important, before scaling to larger areas, to create a clear picture of the yield and cost-benefit of the subirrigation system in relation to the sprinkler system and how the yield can be differentiated to different types of crops and soils. This knowledge should then be included in the information that is provided to the farmers, to generate even more publicity and clarity of the subirrigation system and to make it more attractive. Convincing farmers that the subirrigation system will have more advantages than the sprinkler system is necessary to make further scaling possible. This falls together with what resulted from this research, that farmers can be seen as a bit conservative in their perception of climate change but more importantly conservative to implement innovations in their daily practices. Making the subirrigation system more common for the group of farmers can help to overcome this conservatism towards the implementation of innovations.

The last lesson that was learnt for developing a scaling strategy, is that scaling of the subirrigation system in Stegeren does involve different actors and more importantly which actors are important for the scaling of the subirrigation system in Stegeren. Despite the fact that this research focused on the promoting and constraining conditions from a farmer's perspective, it became evident that other actors, such as the Waterboard Vechtstromen, do have an influence if conditions work in a constraining or a promoting way for the farmer. For example, the waterboard Vechtstromen has a green board which results in more nature-inclusive agriculture. This leads to the

consequence of less availability of surface water for the subirrigation system in the long term.
On the other hand, the waterboard Vechtstromen promotes the implementation of the subirrigation system which could ease the implementation of the subirrigation system on a larger scale in the area of Stegeren.
The obtained knowledge about different actors helps to develop a scaling strategy for the subirrigation system because, to make scaling of the subirrigation system possible, not only farmers as actors need to be taken into account. A broader perspective on different actors is therefore necessary and what the influence of those actors (in promoting or constraining conditions) is on the scaling of the subirrigation system in Stegeren. Despite the fact that this research had a focus on farmers, the research contributed to delivering this broader perspective.

To conclude, this research uncovered what the promoting and constraining (sub)conditions are for the adoption of the social practice of subirrigation in Stegeren and how these sub-conditions are intertwined with each other. This obtained knowledge about these (sub)conditions is outlined as ‘lessons’ that serve as handles for the development of the scaling strategy of the social practice of subirrigation in Stegeren. By using these handles and providing these lessons a scaling strategy for the social practice of subirrigation in Stegeren could be developed.

5. Conclusion and discussion

In this last chapter an answer to the main research question will be formulated. After an answer is provided, the implications, limitations and recommendations of this research will be discussed.

5.1 Conclusion

This research was carried out by conducting a qualitative approach which took the form of a case study. In this case study, different respondents were approached to do semi-structured interviews and observations. These respondents were the water level manager of the waterboard Vechtstromen and the farmers, situated in and around the area of Stegeren. This gathered information that derived from these semi-structured interviews and observations, helped the researcher to answer the sub-questions. By formulating an answer to the sub-questions, the following main question can be answered:
Which conditions promote and what conditions constrain the adoption of the social practice of subirrigation by the farmers' community in Stegeren and how can this knowledge be used to develop a scaling strategy for this social practice?

This research aimed to develop a scaling strategy for the social practice of subirrigation in Stegeren. To be able to develop a scaling strategy, the constraining and promoting conditions, split out into the three elements of the social practice theory, had to be researched first. Then, with this knowledge, a scaling strategy for the social practice of subirrigation in Stegeren could be developed.
In general, this research aimed to contribute to how the social-practice approach can help to understand the conditions related to the decision whether to (not) adopt the innovation, and thus the new social practice of subirrigation. Since most of the theoretical frameworks only set out the process of how innovations can be implemented in practice but do not describe how the probability can be increased to adopt those social practices by understanding the promoting and constraining conditions that are behind those decisions to (not) adopt the social practice.
To return to the theoretical approach in this research, the three elements of the social practice of subirrigation were researched to see how these three elements influenced the adoption of this social practice. During the research, it became clear that all the three elements have promoting and constraining (sub)conditions that influence the adoption of this social practice in Stegeren. It is important to state that these (sub)conditions are derived from a farmer's perspective, thus how the adoption of this social practice can be constrained or promoted from a farmer's point of view. This makes it possible to ultimately answer the main research question which is stated earlier.

To begin with, the type of soil and the soil condition play a big role to make further adoption of this social practice possible. Stegeren has mostly sandy soils, which is not the best soil to use the subirrigation system with. This resulted in the consequence that the adoption of the social practice of subirrigation in Stegeren is already experiencing more difficulty. Even if farmers do have proper soils, the sub-condition of available surface water, which can be approached as crucial, has to be fulfilled. Whereby farmers, as described earlier, can be constrained in two ways: having plots without access to surface water and the growing importance of nature and the aim to have more nature-inclusive agriculture in Stegeren. Besides these sub-conditions, the ownership/tenantship together with the type of crop on the plot and the investment costs of the subirrigation system can be approached as constraining for the further adoption of this social practice.

On the other hand, promoting sub-conditions such as the effectiveness of the groundwater regulation with the subirrigation system, less labour and fuel costs, possible subsidies and other (economic) incentives, can help to promote the adoption of this social practice in Stegeren.
Nonetheless, even if these constraining (sub)conditions are dealt with and despite other promoting (sub)conditions, further adoption of the social practice of subirrigation is not possible at this moment in Stegeren. Since there is no 'water demand space' available to install more subirrigation systems. This means that Stegeren reached its limit of the water capacity in the area.

Furthermore, this research showed that economic (sub)conditions are more important than climatic (sub)conditions, as well in a promoting way as in a constraining way. Despite the greater importance of economic conditions, the (historic) attitude of farmers towards climate change and the severity of its consequences plays also a constraining role in the adoption of the subirrigation system.
The most important sub-condition from an economic perspective, which is partly constraining a lot of farmers to adopt subirrigation, is the lack of a clear yield in comparison with a sprinkler installation and the lack of a cost-benefit analysis of the subirrigation system itself. In this research, this constraining sub-condition was described as the 'black box of yield and cost-benefit'.

Nevertheless, the subirrigation system itself is simple, no significant new knowledge or skills were necessary to obtain, which resulted in an easy-to-operate and independent use of this subirrigation system by the farmers. This independent use of the system can be altered when technical errors occur, to fix these technical errors farmers rely on KLIMAP, however outside the pilot study this is not possible. To make further adoption of this social practice possible, a solution has to be thought of to sort out this constraining sub-condition.

At last, farmers have a high valuation of this pilot study. Despite the overall good assistance of KLIMAP in this pilot study, most farmers shared that it is a big loss if not the maximum results will be achieved from this pilot study. Striving for and achieving the maximum results will help to understand how further adoption of the subirrigation system is possible.

All this obtained knowledge about the constraining and promoting sub(conditions) for each of the three elements of the social practice of subirrigation in Stegeren will contribute to developing a scaling strategy for this same social practice because the promoting and constraining conditions are now revealed.
Because of this exposure, it is made clear which (sub)conditions are necessary to take into account, from a farmer's perspective, to make further scaling of subirrigation possible in Stegeren.

To conclude, it can be said that Stegeren is not the ideal area to test this innovation of subirrigation, however, by testing subirrigation in a less 'suitable' area, important promoting and more importantly constraining sub-conditions can be found which can be used to make further adoption possible in Stegeren and other areas. The technique of the subirrigation system works but is still surrounded by vagueness at some points. This research has made clear what this vagueness is, in terms of the different constraining (sub)conditions that were found.
For a farmer to adopt the social practice of subirrigation in Stegeren, a lot of different (sub)conditions have to be met, external (sub)conditions as well as internal (sub)conditions. How 'strong' these promoting and constraining (sub) conditions really are in practice and how these (sub)conditions precisely differ for each farmer has yet to be researched.

5.2 Discussion

Now that the promoting and constraining (sub)conditions concerning the social practice of subirrigation in Stegeren are revealed and an answer is provided to the main question. This last paragraph will provide a critical reflection on the implications, limitations and recommendations of this research.

5.2.1 Implications of the research

As stated earlier in this research, present theoretical frameworks only set out the processes of how innovations could be implemented into practice.
Nonetheless, this research focused on the (sub)conditions related to the decision whether to (not) adopt these innovations, and thus new social practices, by the users of those innovations/social practices. This research made it clear which (sub)conditions are in place that promote or constrain the adoption of the innovation of subirrigation by the user of this innovation. Before the commencement of this research, fewer (sub)conditions were expected that could influence the adoption of this social practice of subirrigation.

This was caused by the fact that not much literature is in place about general promoting and constraining conditions related to the adoption of the subirrigation and especially from a farmer's perspective.
This research proved that many promoting and constraining (sub)conditions are important for the adoption of the social practice of subirrigation.
By obtaining this extra knowledge about both the types of conditions a better picture was formed of how the social practice of subirrigation in the area of Stegeren and (possibly) outside this area can be upscaled.

Furthermore, this obtained knowledge will help the KLIMAP project to answer their question on the upscaling issue of subirrigation in the area of Stegeren. Since it became clear what (sub)conditions are important to take into account to make further upscaling possible and what could constrain the upscaling process in Stegeren.

Next to the empirical insights that this research delivered, the research also pointed out the importance of the user of this innovation, the farmer in this case, and in general the importance of the user in every pilot study. The research made it clear that the user of an innovation is at least as important as the implementation of that same innovation since the user determines if the innovation is good enough to be further adopted. By gaining more knowledge on why users want to adopt an innovation or not, more knowledge on the scaling of this same innovation will be obtained. Which ultimately will make it easier to upscale innovations from a pilot study to a broader area.

To place this implication in context, KLIMAP is now provided with more information on the (sub)conditions that are important for the adoption of subirrigation, by the farmers, in Stegeren. This knowledge will increase the possibility for the upscaling of the subirrigation system in Stegeren and could help KLIMAP in realizing its scaling process.

At last, this research showed how the social practice approach can be used to research promoting and constraining conditions for the adoption of social practices in general and how the social practice approach can be placed in the field of adoption whereby adoption was approached as a decision and not as a process. The social practice theory was used as a helpful 'mechanism' that enabled the researcher to study this earlier mentioned decision, the adoption of the social practice of subirrigation. The knowledge that this research produced on how the social practice theory of Shove et al., (2012) in combination with the literature on adoption, could help other (future) researchers who want to use the social practice approach in combination with the literature on adoption and how this can help to make further scaling possible.

The social practice approach together with the social practice theory of Shove et al., (2012) turned out to be effective for researching the promoting and constraining conditions concerning the adoption of the subirrigation system. Because the social practice approach permitted to conduct an in-depth analysis of a specific social practice, subirrigation in this research. By doing an in-depth analysis it was possible to research how the 'why' and 'how' of practices of irrigation change, why farmers carried out these practices and how these practices have developed over time (Shove, 2004) (Shove & Pantzar, 2005) (Strengers, 2010).

5.2.2 Limitations of this research

Since every research has its limitations, during this research the researcher also encountered different limitations. This subparagraph will further elaborate on the theoretical and methodological limitations that occurred during this research.

Theoretical limitations

As explained at the beginning of this research, the social practice approach together with the social practice theory of Shove et al., (2012) was used for conducting this research. As described in paragraph 2.6.4, social practices, are most of the time, context-specific and personal. Which led to the consequence that there is no general account of variables for each of the elements (Holtz, 2014) (Schatzki & Cetina, 2001) (Higginson et al., 2015). This caused that a full operationalisation of the social practice theory was not possible. During the research, it turned out that for the elements of material and competence this was not such a limitation. Since these elements can be approached as more general and applicable to more farmers.
For example, the type of soil and the availability of water in Stegeren is applicable to all farmers in this area.
The meaning element, on the other hand, are mental activities, motivational knowledge and emotions of individual persons causing that this element differentiates for each farmer (Reckwitz, 2002). Because the fact that the meaning element differentiates for almost all the farmers, a decent operationalisation of this element was difficult and therefore made the measurement of this element hard in practice.

One way to tackle this limitation is by using previous literature on how the social practice approach can be used to research the social practice of subirrigation and especially from a farmer's point of view. However, there is a general lack of literature on how the social practice approach from Reckwitz and Warde together with the social practice theory of Shove et al., (2012) could be used for the social practice of subirrigation. This lack of literature is mostly centred around the promoting and constraining (sub)conditions that are related to the social practice of subirrigation. Despite the explorative character of this research, important promoting and constraining (sub)conditions could have been overlooked, since most of the promoting and constraining (sub)conditions stem from within this research. If more previous research was done on the promoting and constraining (sub)conditions for the social

practice of subirrigation, these conditions could have been used in this research to test these (sub)conditions in the area of Stegeren. To ultimately come to a more general scaling strategy of the social practice of subirrigation. Therefore the lack of literature on the social practice theory in combination with the social practice of subirrigation can be approached as the second theoretical limitation.

Thus, despite the fact that the social practice theory of Shove et al., (2012) was effective to use for researching the promoting and constraining (sub)conditions related to the adoption of this social practice in Stegeren, as described in paragraph 5.2.1. The limitations of the social practice theory and social practice approach are mostly centred around the fact that this approach and theory are used to perform a highly contextual analysis that prevents generalizations of the results which otherwise could be drawn from quantitative datasets (King, Booth, & Lamond, 2014).
Nevertheless, in order to research how practices can change (from irrigation to subirrigation) and thus to make further scaling of subirrigation possible, it was necessary to research the complexities of daily life and those practices of the farmer in depth which was done in this research.

Methodological limitations
The first methodological limitation consists of the complexity of the pilot study in Stegeren which is strenuous to explain simply on paper. The social practice of subirrigation is one practice, however, this practice is influenced by a lot of different external factors and other practices. The occurrence of external factors on the social practice of subirrigation made it more difficult to explain how it influences the social practice of subirrigation from a farmer's perspective.

Every farmer is an individual person, which experiences different (and sometimes unique) promoting and constraining (sub)conditions related to subirrigation. To keep this research manageable, the researcher only focused on the more general promoting and constraining (sub)conditions that emerged during the interviews and observations. This leads to the consequence that there are still promoting and constraining (sub)conditions in the data which are not further elaborated on in the results paragraph of this research.

Moreover, since the researcher chose to only focus on the more general promoting and constraining (sub)conditions and what these conditions are, it can be said that the replication of the case study is more difficult to do.
Researchers who want to replicate this research could focus on other (sub)conditions than the researcher did in this research. This could lead to the consequence of obtaining some different (sub)conditions and therefore different results when the research is being replicated.

Finally, farmers could also elaborate more on other promoting and constraining (sub)conditions than they did now in this research. Since the attention and experience on promoting and constraining (sub)conditions of the farmers related to subirrigation also shift from time to time. This could also cause different results than the results that were acquired in this research.

5.2.3 Recommendations for further research practice/ future research

To prevent that limitations that occurred during this research together with questions that were raised in this research would occur again, recommendations are described below. These recommendations are divided in recommendations for future research and recommendations for practice.

Recommendations for future research

It is clear that further adoption of the social practice of subirrigation and therefore the scaling of the innovation of subirrigation is encountering different constraining (sub)conditions that have to be dealt with first.

Besides the constraining (sub)conditions, the promoting (sub)conditions of this same social practice were also researched. However, both the promoting and constraining conditions related to subirrigation were from the perspective of the farmer. It is plausible that these farmer-related conditions are influenced by and influence other conditions that lie outside this perspective of the farmer, which are important for the scaling of subirrigation.

Therefore, the first recommendation for future research is to investigate what other conditions, outside the farmer's perspective, are of influence that can constrain or promote the scaling of subirrigation and how these conditions relate to the conditions that were found in this research. By doing this, an even better and more complete analysis is available that can help to make further scaling of subirrigation in the area of Stegeren possible.

This research made clear that some conditions that were found, are of great importance for the farmers to make the adoption of subirrigation possible. The perspective of the user of an innovation can therefore be seen as crucial.

However, many theoretical frameworks that are already in place only set out the process of how those innovations can be implemented in practice and do not involve the user side of those same innovations.

Therefore, the second recommendation for future pilots of innovations is that, besides the implementation and testing of innovations, more attention should be paid to the user of the innovation. For example, this could be in the form of an in-depth analysis of the users of innovation pilots during the pilot phase of those innovations, as was done in this research.

Ultimately, this in-depth analysis could help to discover promoting and constraining conditions that were not discovered if this analysis would not been done.

Which could help to have a more fluent implementation of the innovation after the pilot phase is finished.

The third recommendation for future research is the expansion of the scope of this research to other areas where the innovation of subirrigation is being/will be implemented. By expanding the scope and doing research more constraining and promoting sub-conditions could be discovered for the social practice of subirrigation By expanding the scope of this research, the development of a more general scaling strategy for the social practice of subirrigation is possible, to the extent this is feasible.

At last, further research is necessary to make a prioritisation of the obtained promoting and constraining conditions. By prioritizing these conditions it will become clear which conditions a more constraining than other conditions and therefore more important to pay attention to. Moreover, by doing prioritization, it will also become apparent what the most promoting conditions are for further scaling of this social practice.

Recommendations for practice
The first recommendation for practice that derives from this research is the advice to KLIMAP to put more effort into the pilot study of Stegeren. As described earlier, probably more and better results will derive from this pilot study if more attention is being put into this pilot study.

Secondly, more (positive) publicity has to be generated for the subirrigation system in the area of Stegeren to make further scaling possible. Since it resulted in this research that the majority of the group of farmers do not have enough knowledge to make a considered choice about the adoption of the subirrigation system.
This publicity should at least include a yield and cost-benefit analysis of the subirrigation system and the advantages of the subirrigation system in comparison with a sprinkler system.

Moreover, to make the second recommendation possible and to ultimately make scaling of the subirrigation system possible in the area of Stegeren, KLIMAP has to do more research on what the cost-benefit and its yield of the subirrigation is in comparison with a sprinkler system, divided for the different types of crops and soils farmers have.

Finally, to make adoption of the social practice of subirrigation and thus further scaling of the subirrigation system possible, more technical information on how the system works and instructions on how to repair possible technical malfunctions should be provided. In this research the KLIMAP farmers stressed the fact that they barely have any technical knowledge of the subirrigation system and advised the researcher ,when implementing this system outside the pilot study, to provide extra technical information for the farmers who want to install the subirrigation system.

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Appendices

Appendix 1. Interview guide for farmers who are involved in the pilot study

Inleiding

In dit interview wil ik u een aantal vragen stellen met betrekking tot subirrigatie. Deze vragen gaan over uw ervaring met subirrigatie en waarom u voor deelname aan deze pilot hebt gekozen.

Mijn eerste vraag is of u bezwaar heeft tegen de opname van dit gesprek. De reden dat ik dit vraag is dat een opname mij kan helpen bij het uitwerken van dit interview.

(Opname aan)

Mijn tweede vraag is of u er mee instemt dat ik de resultaten van dit interview verwerk in mijn onderzoek en dat dit onderzoek ook openbaar toegankelijk zal zijn. Als laatste wil ik u vragen of u als geïnterviewde, bij achternaam, in dit onderzoek genoemd wilt worden.

Als u dat goed vindt, wil ik nu beginnen met het interview. Voelt u zich vrij om vragen te stellen wanneer iets onduidelijk is. Bovendien, als u een vraag echt niet wilt beantwoorden, bent u vrij om te weigeren. Verder zijn er geen foute of goede antwoorden.

Basis informatie vragen

1. Wat is uw naam?

2. Kunt kort omschrijven wat voor type agrarisch bedrijf u heeft en hoelang u al boer bent?

3. Hoeveel hectare is uw bedrijf op dit moment en hoe groot is het perceel waarop subirrigatie van toepassing is?

Introductie vragen

4. Hoe bent u betrokken geraakt bij de pilot study in Stegeren?

5. Welke ervaringen heeft u tot nu toe met deze nieuwe manier van irrigatie?
Is dit een geslaagde pilot voor u?

6. Zo ja, waarom wel? En zou u subirrigatie ook voor de rest van uw perceel willen gebruiken?

7. Bent u verrast, in positieve en/of negatieve zin, door de uitkomsten van deze pilot tot nu toe?

Diepte vragen (social practice theory and adoption)

De volgende vragen gaan in op de verschillende redenen waarom u voor een deelname aan de pilot studie heeft gekozen.

Material

8. Wat was er nodig om de aanleg van het subirrigatie systeem op uw perceel mogelijk te maken?

9. Welke factoren zijn van invloed op de werking van het subirrigatie systeem? *(Bodemtype en bodemconditie, locatie van perceel t.o.v. het grondwater, constructie van het subirrigatie systeem, genoeg beschikbaar grondwater, gewas gezondheid, kwaliteit en gewas ziektes)*

Competence

10. Is het makkelijk om met dit subirrigatie systeem te werken? *(Bruikbaarheid van het systeem)*

11. Heeft u nog veel kennis en vaardigheden moeten aanleren? *(Vaardigheden om het systeem te beheren en te gebruiken)*

12. Kunt u algemeen iets zeggen over hoe u door KLIMAP bent begeleid hierin of buiten KLIMAP om?

13. Kunt u nu zelfstandig uw akker ‘subirrigeren’? *(Bruikbaarheid van het systeem)*

Meaning

14. Wat is volgens u een ‘goede boer’?

15. Waarom heeft u besloten om aan deze pilot deel te nemen en wat zijn uw belangrijkste redenen hiervoor geweest? (*Klimaat gerelateerd, economisch gerelateerd, gewas gerelateerd)*

16. Heeft u nog getwijfeld om aan deze pilot mee te doen? Waren er bijvoorbeeld nog enkele risico’s waar u eerst een afweging van wilde maken?
17. Hoe is de waarde van water ten opzichte van vijf jaar geleden veranderd voor u?

Scaling of subirrigation

18. Weet u of er al andere boeren in de omgeving zijn die subirrigatie willen gaan gebruiken? Zo ja, wat denkt u dat de belangrijkste reden(en) hiervoor zijn?

19. Wat zal uw advies zijn aan de boeren die met subirrigatie aan de slag willen gaan?

Als laatste wil ik u nog bedanken voor de deelname aan interview. Als u verder geen vragen meer heeft voor mij, zet ik de opname op stop en is dit interview afgelopen.

Appendix 2. Interview guide for farmers who are not involved in the pilot study and are familiar with subirrigation

Inleiding

Zoals u weet zorgt de toenemende verandering van het huidige klimaat voor steeds meer droogte in Nederland, ook de akkers van boeren ondervinden hier hinder van. Een van de oplossingen om deze droogte van akkers tegen te gaan is subirrigatie, oftewel omgekeerde drainage.

Mijn eerste vraag is of u bezwaar heeft tegen de opname van dit gesprek. De reden dat ik dit vraag is dat een opname mij kan helpen bij het uitwerken van dit interview.

Mijn tweede vraag is of u er mee instemt dat ik de resultaten van dit interview verwerk in mijn onderzoek en dat dit onderzoek ook openbaar toegankelijk zal zijn en of u als geïnterviewde, bij achternaam, in dit onderzoek genoemd wilt worden.

Als u dat goed vindt, wil ik nu beginnen met het interview. Voelt u zich vrij om vragen te stellen wanneer iets onduidelijk is. Bovendien, als u een vraag echt niet wilt beantwoorden, bent u vrij om te weigeren. Verder zijn er geen foute of goede antwoorden.

(Opname aan)

Basisinformatie Vragen

1. Wat is uw naam?

2. Kunt kort omschrijven wat voor type agrarisch bedrijf u heeft en hoelang u al boer bent?

3. Hoeveel hectare is uw bedrijf op dit moment?

Introductievragen

4. In welke mate bent u bekend met subirrigatie?

5. Heeft u subirrigatie al een keer overwogen voor op uw perceel?

Diepte vragen (social practice theory and adoption)

De volgende vragen richten zich meer op een eventuele overstap van uw huidige vorm van irrigatie naar subirrigatie en waarom u deze overstap wel of niet zou maken.

Material

6. Is uw land geschikt om subirrigatie succesvol te laten zijn? *(Bodemtype en bodemconditie, locatie van perceel t.o.v. het grondwater)*

7. Welke zou uw perceel geschikt zijn om een eventuele overstap naar subirrigatie te maken? *(locatie van perceel t.o.v. het grondwater, constructie van subirrigatie systeem, genoeg beschikbaar grondwater, gewas gezondheid, kwaliteit en gewas ziektes).*

8. Waarom zou uw perceel juist niet geschikt zijn om een eventuele overstap naar subirrigatie te maken? *(afval gerelateerd aan subirrigatie systeem(materiaal van drains dat in de grond achter blijft), constructie van het subirrigatie systeem, onvoldoende beschikbaar grondwater, locatie van het perceel t.o.v. het grondwater)*

Meaning

9. Wat is volgens u een goede boer?

10. Waarom zou u gebruik willen maken van subirrigatie? *(Klimaat gerelateerd, economisch gerelateerd, gewas gerelateerd)*

11. Zouden klimaatverandering en toenemende periodes van droogte uw keuze om over te stappen op subirrigatie beïnvloeden?

Competence

12. Denkt u dat het makkelijk is om met het subirrigatie systeem te werken? *(gebruiksvriendelijkheid van het systeem)*

13. Denkt u dat u veel kennis en vaardigheden zou moeten aanleren om een succesvolle overstap naar subirrigatie mogelijk te maken? *(Vaardigheden om het systeem te beheren en te gebruiken)*

14. Denkt u dat het haalbaar is dat u zelf uw akker zal kunnen ‘subirrigeren’? *(Genoeg kennis bepaald gebruiksvriendelijkheid van systeem)*

Scaling of subirrigation

15. Denkt u dat deze redenen voor een eventuele keuze voor subirrigatie ook gelden voor andere boeren of alleen voor u?

16. Wat zijn, volgens u, de belangrijkste redenen om subirrigatie mogelijk te maken bij een boer in het algemeen? En wat zouden de grootste belemmeringen kunnen zijn voor een boer?
17. Wanneer zou een overstap op subirrigatie geslaagd zijn voor u?

Als laatste wil ik u nog bedanken aan de deelname van dit interview. Als u verder geen vragen meer heeft voor mij, zet ik de opname op stop en is dit interview afgelopen.

Appendix 3. Interview guide for farmers who are not involved in the pilot study and are not familiar with subirrigation

Inleiding

Zoals u weet zorgt de toenemende verandering van het huidige klimaat voor steeds meer droogte in Nederland, ook de akkers van boeren ondervinden hier hinder van. Een van de oplossingen om deze droogte van akkers tegen te gaan is subirrigatie, oftewel omgekeerde drainage.
Mijn eerste vraag is of u bezwaar heeft tegen de opname van dit gesprek. De reden dat ik dit vraag is dat een opname mij kan helpen bij het uitwerken van dit interview.

Mijn tweede vraag is of u er mee instemt dat ik de resultaten van dit interview verwerk in mijn onderzoek en dat dit onderzoek ook openbaar toegankelijk zal zijn en of u als geïnterviewde, bij achternaam, in dit onderzoek genoemd wilt worden.

Als u dat goed vindt, wil ik nu beginnen met het interview. Voelt u zich vrij om vragen te stellen wanneer iets onduidelijk is. Bovendien, als u een vraag echt niet wilt beantwoorden, bent u vrij om te weigeren. Verder zijn er geen foute of goede antwoorden.

(Opname aan)

Basisinformatie Vragen:

1. Wat is uw naam?

2. Kunt kort omschrijven wat voor type agrarisch bedrijf u heeft en hoelang u al boer bent?

3. Hoeveel hectare is uw bedrijf op dit moment?

Nu wil ik het met u hebben over subirrigatie. Via subirrigatie, ofwel omgekeerde drainage, is het mogelijk om de grondwaterstand te laten stijgen waardoor de wortelzone van het gewas vochtig blijft. Doordat er voor wordt gezorgd dat de wortelzone vochtig blijft zal het bovengronds beregenen minder vaak nodig zijn en wordt verdroging in de landbouw mogelijk tegengenaan. In de omgeving van Stegeren zijn er op dit moment een aantal boeren, als onderdeel van een groter project, die deze vorm van irrigatie toepassen op hun akker.

Introductievragen

4. In hoeverre bent u bekend met subirrigatie?

5. Als u deze korte uitleg over subirrigatie hoort, klinkt het voor u dan aantrekkelijk om dit subirrigatie systeem op uw perceel te plaatsen?

Diepte vragen (Social practice theory and adoption)

De volgende vragen hebben te maken met uw huidige vorm van irrigatie en wat de redenen zijn om aan deze vorm van irrigatie te blijven te gebruiken of juist een overstap te willen maken naar een andere vorm van irrigatie.

Material

6. Hoe irrigeert u uw perceel op dit moment?

7. Waar moet uw perceel aan voldoen om uw huidige vorm van irrigatie mogelijk te maken? *(Bodemtype en bodemconditie, locatie van perceel t.o.v. het grondwater)*

8. Waarom blijft u op dezelfde manier irrigeren? *(Genoeg beschikbaar grondwater, locatie van het perceel t.o.v. het grondwater, Klimaat gerelateerd, economisch gerelateerd, gewas gerelateerd)*

Meaning

9. Wat is volgens u een goede boer?

10. Zouden klimaatverandering en toenemende periodes van droogte uw keuze om over te stappen op subirrigatie beïnvloeden?

Competence

11. Denkt u dat u voldoende kennis en vaardigheden heeft om met de huidige en toekomstige droogte en waterschaarste om te gaan?

12. Zo nee, in hoeverre heeft u nieuwe kennis en vaardigheden nodig om hier in de toekomst wel mee om te kunnen gaan?

Possible scaling of subirrigation

13. Staat u open voor veranderingen in de manier waarop u met water omgaat?

14. Zou u bereid zijn om in de nabije toekomst uw manier van irrigatie aan te passen?

Als laatste wil ik u nog bedanken aan de deelname van dit interview. Als u verder geen vragen meer heeft voor mij, zet ik de opname op stop en is dit interview afgelopen.

Appendix 4. Interview guide for employees of the Waterboard Vechtstromen.

- *Inleiding*
- *In dit interview wil ik u een aantal vragen stellen over het waterschap de Vechtstromen waarbij u werkzaam bent en hoe u en het Waterschap tegen beregening van akkers en subirrigatie aankijkt. Verder wil ik het met u hebben over de relatie van het waterschap met de boeren.*

Mijn eerste vraag is of u bezwaar heeft tegen de opname van dit gesprek. De reden dat ik dit vraag is dat een opname mij kan helpen bij het uitwerken van dit interview.

(Opname aan)

Mijn tweede vraag is of u er mee instemt dat ik de resultaten van dit interview verwerk in mijn onderzoek en dat dit onderzoek ook openbaar toegankelijk zal zijn. Als laatste wil ik u vragen of u als geïnterviewde, bij achternaam, in dit onderzoek genoemd wilt worden.

Als u dat goed vindt, wil ik nu beginnen met het interview. Voelt u zich vrij om vragen te stellen wanneer iets onduidelijk is. Bovendien, als u een vraag echt niet wilt beantwoorden, bent u vrij om te weigeren. Verder zijn er geen foute of goede antwoorden.

Basis informatie vragen

1. Wat is uw naam?

2. Kunt u kort uw functie binnen het waterschap omschrijven en hoelang u deze al bekleed?

3. Hoe groot is het stroomgebied dat het waterschap de Vechtstromen onder beheer heeft? En hoe groot is het stroomgebied in Stegeren?

Introductie vragen

3. Bent u bekend met het KLIMAP project, dat op dit moment loopt in het gebied Stegeren?

4. Op welke manier bent u hierbij betrokken?

5. Hoe ziet u de relatie tussen klimaatverandering, droogte en water in het gebied Stegeren?

Diepte vragen (subirrigatie, beregening en de rol van het waterschap)

6. Ziet u subirrigatie, in de nabije toekomst, als de vervanger van beregening?

7. Hoe ziet u de rol van het waterschap voor zich omtrent subirrigatie en beregening?

8. Hoe is volgens u de relatie tussen de boeren in het gebied Stegeren en het waterschap?

9. Denkt u dat een goede relatie cruciaal is als het gaat over de aanvoer van water naar de boeren in het gebied?

10. Denkt u dat het waterschap genoeg water kan blijven leveren om elke boer in Stegeren te verzekeren van beregening van zijn land?

11. Zo nee, denkt u dat subirrigatie effectiever, waterbesparender, is om wel in deze waterbehoefte te kunnen blijven voorzien?

12. In welke mate staat het waterschap open voor veranderingen op de manier waarop boeren hun akkers van water voorzien?

13. Hoe zou de relatie tussen het waterschap en de boeren zich vormen als het waterschap niet meer genoeg water kan leveren?

14. Waar zit volgens u het probleem, als het waterschap niet meer genoeg water kan leveren? Bij de boer die beregend of bij het waterschap of ergens anders?

15. Hoe ziet u de relatie tussen klimaatverandering en daarmee gepaarde drogere zomers en beregening van akkers?

16. Denkt u dat natuurinclusieve landbouw mogelijk is?

17. Zo ja, kan subirrigatie hier een bijdrage aan leveren of een belangrijke rol in spelen?

Als laatste wil ik u nog bedanken aan de deelname van dit interview. Als u verder geen vragen meer heeft voor mij, zet ik de opname op stop en is dit interview afgelopen.

Appendix 5. Interview informed consent form

Hartelijk dank dat u mee wilt doen aan het onderzoek over subirrigatie in de dagelijkse landbouwpraktijk, zoals u weet is dit onderzoek onderdeel van het KLIMAP project. Verder wordt dit onderdeel van het onderzoek uitgevoerd als onderdeel van mijn afstudeerscriptie aan de Radboud Universiteit.

Als onderdeel van dit onderzoek, heb ik met u een interview gepland om uw perspectief te kunnen begrijpen en te kunnen verwerken tot een advies hoe subirrigatie op grotere schaal toegepast kan worden. Het interview zal maximaal een uur duren en ik zal dit interview graag willen opnemen. Met al uw uitspraken zal vertrouwelijk worden omgegaan. Alleen ik en mijn (co) supervisor vanuit de universiteit zullen toegang hebben tot de opnames en het transcript van dit interview.

Voor aanvang van dit interview is het belangrijk dat u van de volgende rechten in kennis bent gesteld:

- Alle antwoorden die u geeft zullen alleen gebruikt worden voor dit onderzoek en niet voor andere doeleinden;
- U kunt ten alle tijde beslissen om te weigeren om te antwoorden;
- U kunt ten alle tijde besluiten om te stoppen met dit interview, ook nadat het interview is afgelopen;
- U kunt tijdens de looptijd van dit onderzoek op de hoogte worden gehouden van tussentijdse resultaten. De definitieve versie zal ik uw toesturen na afronding van dit onderzoek;
- Bij resterende vragen over dit onderzoek kunt u contact opnemen via de telefoon (06-30428334) of via mail (teun.maurix@ru.nl)

Tenslotte vraag ik u om onderstaande twee vragen te beantwoorden:

- *Bent u akkoord met de opname van dit interview ten behoeve van het onderzoek?*
  - Ja
  - Nee
- *Mag de onderzoeker uw volledige naam, voor- en achternaam gebruiken in het onderzoek om citaten weer te geven?*
  - Ja, voornaam en achternaam
  - Ja, alleen voornaam
  - Ja, alleen achternaam
  - Nee (anoniem)

Ondergetekenden verklaren dit document gelezen en verstaan te hebben:

Handtekening onderzoeker:	Handtekening respondent:

Naam: Teun Maurix **Stegeren: xx-05-2022** ……

Appendix 6. Codebook interviews

Element	***Operationalisation of the element***	***Condition***	***Codes (sub-condition)***
Material	*Infrastructures, tools, hardware, encompassing objects and the body itself, all physical attributes related to the social practice.*	*Soil-related*	*1. The condition of the soil in relation to a subirrigation system* *2. Soil type* *3. Fertilization of the soil** *4. The flatness of the ground level**
		Non-soil related	*1. Height of the plot in relation to the Vecht** *2. Availability of surface water** *3. (In)suitable ditches for construction of the subirrigation system** *4. The construction of subirrigation system** *5. The draining of redundant water when using the subirrigation system** *6. Ownership/tenantship of the plot** *7. Effectiveness of groundwater regulation with a subirrigation system**
		Value related to the crop	*1. Type of crop** *2. Quality of crop* *3. Weight of crop** *4. Crop diseases*
Meaning	*Social and symbolic significance of participation, ideas, emotions and aspirations related to the social practice.*	*Economic conditions*	*1.The investment costs of the subirrigation system* *2. Income (in)security* *3. Labour costs and fuel costs*

			4. Value of the land property *5. The cost-benefit/yield of subirrigation in comparison with a sprinkler installation** *6. The influence of a possible subsidy for a subirrigation system** *7. Incentives to make a subirrigation system appealing** *8. Moment of installation of subirrigation system**
		Climatic conditions	*1. Impact of climate change on the farmer* *2. Attitude to climate change (Historical argument)** *3. Nature-inclusive agriculture** *4. Nitrogen utilization* *5. The changing value of water for the farmer** *6. The relation between the farmer and the Waterboard Vechtstromen** *7. The relation of the farmer with other farmers** *8. Importance of the KLIMAP project for the farmer and the waterboard Vechtstromen**
		Personal values related to the irrigation systems.	*1. Personal value of the sprinkler system in comparison with the subirrigation system** *2. Personal value related to the subirrigation system** *3. Personal value related to the sprinkler system**

Competence	*Know-how, background knowledge, technique and understanding related to the social practice.*	*Usability of the subirrigation system*	*1. Filters of subirrigation system** *2. Technical malfunctions and technical back-up** *3. Independent use of subirrigation system* *4. Maintenance of the subirrigation system**
		Skills to operate the subirrigation system	*1.Easy to operate the subirrigation system* *2. Need for the acquirement of new skills and knowledge* *3. Already existing knowledge of the subirrigation system** *4. The assistance of KLIMAP to the farmer in this pilot study**

** These codes do not stem from the literature but were found during the interviews and the observations. These codes are important enough to incorporate into the codebook.*