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CHANGING THE CLIMATE ADAPTATION NARRATIVE

USING LANDSCAPE VALUES AS A BOTTOM-UP APPROACH TO DETERMINE ADAPTATION TURNING POINTS

M.SC. THESIS BY MARIJKE NELLA JOSIEN SCHIPPER

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WATER SYSTEMS AND GLOBAL CHANGE GROUP

Changing the Climate Adaptation Narrative

Using landscape values as a bottom-up approach to determine adaptation turning points

Master Thesis Water Systems and Global Change Group in partial fulfillment of the degree of Master of Science in International Land and Water Management at Wageningen University, the Netherlands

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Bregje van der Bolt

ABSTRACT

To cope with the uncertainty and complexity of climate change, approaches such as climate adaptation pathways have grown in importance within Dutch governmental management. Climate adaptation pathways increase flexibility within the decision-making process. Within this approach, the vast majority of the thresholds are top-down and technically or politically decided upon. This non-participative nature of the adaptation narrative hinders the development of widely supported strategies. Hence, social and bottom-up established thresholds are needed to regulate risk to a local perspective. This research offers new insights into on how a values-based approach may guide future adaptation turning point analyses for drought. It does this by focusing on the landscape values of farmers living in the area around the Mariapeel, Limburg, informed by questionnaire surveys, interviews and climate models. The assessments on landscape values and climatic data infer that the economic value, the life-sustaining value, the future value and the identity value may be compromised in the future to the point that farmers will act upon this change. The exact turning points remain uncertain; instead, the results stress the continuous improvement of the monitoring system and a critical evaluation of drought indicators. All things considered, the approach offers a simple entry point for researchers and local governments to implement measures at a speed in line with local stakeholders' experiences and values.

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This thesis would not have been possible if Jan Classens did not go out of his way to help me distribute the survey to other farmers in the region. I also want to express my gratitude to the farmers who took the time to fill out my survey and were willing to do an interview.

I also want to thank all my friends who have had to read through pages upon pages of, let's be honest, pretty terrible first, second, and third drafts. Thank you Aditi, Annemijn, Charlotte, Claudia, Irene, Nienke, and so many others.

If I have to start listing all the people who have helped me during this thesis, if only to keep me somewhat sane, I would need another 60 pages. And I am pretty sure that the people in question prefer I did not do that to the trees essential to mitigate climate change.

Finally, this thesis is dedicated to Nel Boonstra-Wijma. You would have been an amazing landscape architect were you given a chance. I know that this dedication does not even come close to ease the pain and the envy of all the chances you did not get. Even so, I hope it gives you some consolation that your granddaughters are seizing the opportunities they have been given.

TABLE OF CONTENTS

1 INTRODUCTION

In the past five years alone, the Netherlands has seen record breaking droughts (Büntgen et al., 2021). These extreme events caused significant damage, mainly in the agricultural sector. The decline in water availability is a growing cause for concern for all sectors dependent on the water system (Planbureau voor de Leefomgeving, 2012). Drought is a complex, slow-onset phenomenon that is difficult to predict because changes in rainfall patterns and evapotranspiration are erratic (Field, Barros, Stocker, & Dahe, 2012). Climate change-induced drought projections are accordingly highly inconsistent and uncertain, particularly for the Netherlands (Field et al., 2012; Sluijter, Plieger, van Oldenborgh, Beersma, & de Vries, 2018). In contrast, the newest high-resolution climate models show significant changes in air temperature and radiation, tentatively predicting an increase in climate change-induced droughts, particularly inland (KNMI, 2020; Philip, Kew, van der Wiel, Wanders, & van Oldenborgh, 2020; Rousi, Selten, Rahmstorf, & Coumou, 2020; Spinoni, Vogt, Naumann, Barbosa, & Dosio, 2018; van der Linden, Haarsma, & van der Schrier, 2019). For most Dutch people, the risks of climate-induced droughts may be abstruse, for it is unprecedented. However, assuming that the most extreme climate scenario[1] becomes reality, Planbureau voor de Leefomgeving (2012) expects the first bottleneck in the current water-use and infrastructure to appear before the year 2050, inhibiting the freshwater supply. As a result, the everlasting struggle between the Netherlands and water will find itself in dire straits. The triumphalist national motto *je maintiendrai* [I shall maintain] will not do anymore. The time has come for a more durable and robust water system that can resist potential droughts incited by climate change. There is a need for climate adaptation in the face of uncertainty.

Due to the urgent need for climate adaptation, approaches such as Dynamic Adaptive Policy Pathways (DAPP) have gained traction within governmental management ("Dynamic Adaptive Policy Pathways," n.d.). DAPP increases the flexibility within the decision-making process, despite the uncertainty and complexity of climate change. Within the adaptation pathways approach, most thresholds are technically or politically determined and top-down (Barnett, Graham, et al., 2014). This overlooks the knowledge and values of people who are not involved in the decision-making process but who are affected by the decisions made (Barnett, Graham, et al., 2014; Tschakert et al., 2017; Wise et al., 2014). Because a non-participatory approach makes it difficult to develop widely supported strategies, there is a need for social and bottom-up established thresholds to regulate risk to a local vision (Barnett, Graham, et al., 2014). The need for bottom-up thresholds not only arises because adaptation measures often have a significant impact on their local living environment, but also the successes of adaptation measures largely depend on farmers' support (Graaf, 2020). Because farmers are big water users, they are often the implementing parties of these top-down measures and strategies. A region where this problem is recognized is the Mariapeel, Limburg. A way to look at social and bottom-up established thresholds is to use landscape values. Landscape values define as the socio-cultural significance people allocate to a particular physical location (Novaczek, MacFadyen, Bardati, & MacEachern, 2011). Accordingly, the willingness to accept adaptation measures depends on the moment the landscape values vital for farmers' well-

[1] Characterised by a high increase in global temperature and a high change in air circulation pattern.

being are compromised (Barnett, Graham, et al., 2014). To attend to this need, this research will focus on values, particularly landscape values of farmers, in the region of the Mariapeel, Limburg.

The purpose of this research is to contribute to the limited scientific literature of social and bottom-up established thresholds by exploring whether it is possible to use landscape values as thresholds for social turning points. It provides a unique perspective on how landscape values may guide future climate adaptation strategies based on adaptation pathways and turning points. The research is among the first to use landscape values to determine socially relevant turning points in The Netherlands. Moreover, it is the first study to use landscape values to establish socially determined turning points for climate change-induced drought. From this previous objective arises the following research question: *Can landscape values be translated into thresholds for adaptation turning points of farmers in the Mariapeel, Limburg?*

2 THEORETICAL FRAMEWORK

This chapter aims to demonstrate the rationale behind the topic of this study. Accordingly, several core theoretical principles within climate adaptation studies are critically appraised, namely *drought, adaptation pathways*, *turning points*, and *landscape values*. These key concepts are defined, and their intersection as well as the relevance concerning the proposed inquiry, are described.

2.1 Decision-making in the face of drought uncertainty

Dutch governance on the national and regional level initiates inventories for adaptive measures to establish a climate-robust water system. A few examples of these initiatives are *Het Nationaal Waterprogramma* [The National Water Program], *Het Regionaal Waterprogramma* [The Regional Water Program], *Het Waterbeheer Programma* [The Water Management Program], *het Deltaplan Hoge Zandgronden* [The Delta Plan Elevated Sandy Soils] and *Het Deltaplan Ruimtelijke Adaptatie* [The Delta Plan on Spatial Adaptation]. Considering the above, a substantial amount of effort is already being made concerning climate adaptation. Nevertheless, it is difficult to anticipate which strategies are efficient because the effects of climate change are difficult to predict (Haasnoot et al., 2020; Haasnoot, Kwakkel, Walker, & ter Maat, 2013), particularly for drought (Field et al., 2012).

Drought is an elusive concept; there is no universal definition (Lloyd-Hughes, 2014). It is a complex phenomenon that has generated various definitions and many more indicators for the identification thereof (Mukherjee, Mishra, & Trenberth, 2018). Amongst researchers there is no consistent way to define or identify the phenomenon, operationally or conceptually (Slette et al., 2019). Various indices have been designed as an ad-hoc indicator to determine a specific drought, whether it be a meteorological drought (deficit in soil moisture), hydrological drought (low water supply), socio-economic drought (deficit in economic or agricultural commodities dependent on water) or agricultural drought (crops become affected) (Mukherjee et al., 2018; Slette et al., 2019). Because there are many ways to define and identify drought, there is something to be said about every indicator. Added to this, drought is difficult to predict. Merely looking at drought as a physical process, the phenomenon depends on numerous factors such as atmospheric circulation, oceanic circulation, topography, and nonlinear land-ocean-atmosphere feedback processes (Mukherjee et al., 2018). Climate models can never produce completely accurate projections. The simplest way to look at drought is meteorological drought because the least amount of indicators are used to project it (Sepulcre-Canto, Horion, Singleton, Carrao, & Vogt, 2012). Given that this research is a proof-of-principle, aimed at testing the possibility of translating landscape values into thresholds for turning points, the most straightforward drought definition suffices and is deployed. Notwithstanding, predictions remain uncertain as it is unknown how drought is going to develop in the future.

Consequently, strategies based on the 'most probable future' may be unsuccessful in reducing the effects of climate change if another 'future' becomes a reality. In response, policy makers have to adapt to a 'new future' (Haasnoot, Middelkoop, Offermans, Van Beek, & Van Deursen, 2012). Policies, strategies and measures on climate adaptation have to be easily flexible and highly responsive towards uncertain changes (Wise et al., 2014).

Moreover, actions cannot be taken in seclusion but should progress throughout the future. An additional complication arises as quick implementation of many measures is impeded by the significant and long-lasting consequences of these measures. For this reason, it is necessary to include long-term objectives in near-term decisions (Haasnoot et al., 2013). Despite these uncertainties, decisions need to be made.

2.2 The path to adaptation pathways

In response to these uncertainties, researchers developed a methodology called adaptation pathways (Haasnoot et al., 2013). This method results in pathways that highlight various strategies for a particular change, carried out by a series of actions over time. Instead of focusing on the outcome of a particular action, the concept stresses the development of decision-making. As a result, it emphasizes and helps visualize adaptation and flexibility within the decision-making process, despite the uncertainty and complexity of climate adaptation (Wise et al., 2014). Although there are multiple approaches to adaptation pathways (Colloff et al., 2016; Haasnoot et al., 2013; Reeder & Ranger, 2011; Wise et al., 2014), this thesis expands on the approach developed by Haasnoot et al. (2013) called 'Dynamic Adaptive Policy Pathways'. The reason behind this is that this particular approach has gained traction as an inspiration and guide for the current Adaptive Delta Management Program of the Dutch Government ("Dynamic Adaptive Policy Pathways," n.d.).

The approach eventually results in multiple storylines. Each storyline is assessed based on natural events and socio-economic perspectives compiled in pathways (Haasnoot et al., 2013). Adaptation pathways are an approach to adaptive planning that display a series of actions over time. This series of actions can change based on new knowledge or developments. The advantage of using this approach is that the different storylines demonstrate what strategies are sustainable. Moreover, it considers climate change and adaptation uncertainty by giving insights into possible lock-in situations. Figure 3 displays such a pathway (Haasnoot et al., 2012).

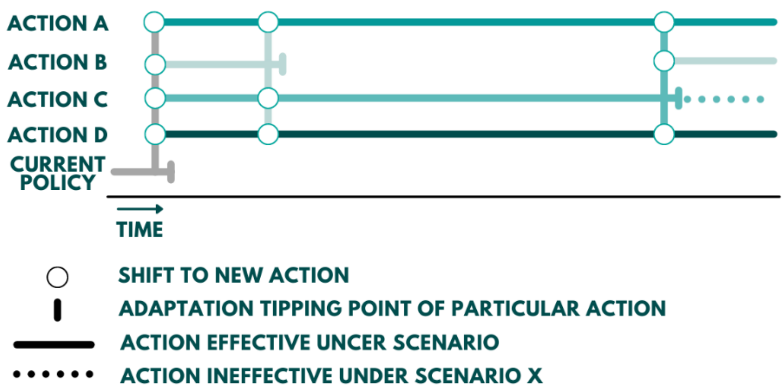

Figure 2.1 Adaptation Pathways Map, as adapted from Haasnoot et al. (2012).

To illustrate, the map starts with the current situation (grey) by means of the current policy. After approximately four years, the current policy is insufficient to reach the intended goal. This is where you see the sign for the adaptation tipping point of an action. By that time, action A or D can be taken to meet the objective for the next 100 years. Both action B and C will be sufficient for an additional 84 years before another adaptation tipping point is reached, and action needs to be taken. As shown in scenario X, action C is no longer sufficient, which prompts the change towards action A, B or D. The junctions visualized in Figure 2.1 are called 'adaptation tipping points' (Haasnoot et al., 2012). Tipping points are an inherent concept within this approach and are the focus of this research. This study does not consider the other steps in the DAPP approach.

2.3 Turning up the turning points

An adaptation tipping point symbolizes a point in time in which an action can no longer meet a biophysical or social-political objective and therefore needs to be changed (Werners et al., 2013). Because the term 'tipping point' is also used to describe a shift in an ecosystem to a new state, the term 'turning point' is deployed as the more suitable term to prevent confusion (Werners et al., 2018). Therefore, the rest of the text refers to these junctions as turning points. Werners et al. (2013) noted that turning points are a useful concept because it generates:

> a dialogue between science and policy about why people care, how much stress a system can absorb before an unacceptable situation is reached, when this is likely to happen, and what can be done, that is, how to sustain conditions for social–environmental activities in the face of uncertainty and change. (p. 338)

The situation in which change becomes unacceptable is called a 'threshold'. Thresholds can be either political or social, based on a policy objective or a more informal social or communal interest (Werners et al., 2013). Thresholds are of importance as it gives an indication of whether adaptation management strategies are able to withstand climate change and when changes are needed. A turning point and threshold visualization are given below in Figure 2.2.

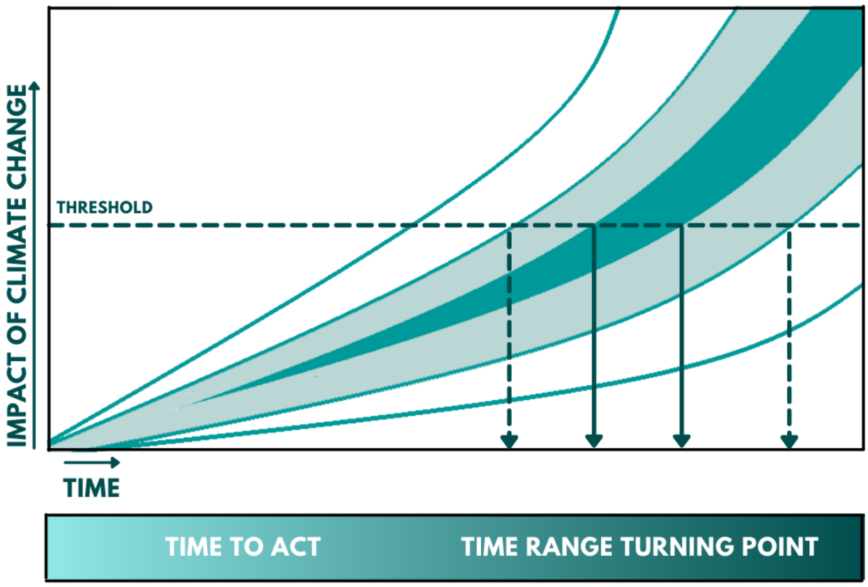

Figure 2.2. *A schematic diagram of the turning point concept, derived from Werners et al. (2013). A threshold is set at a particular value for which a climate change impact is likely to bring about intolerable conditions. The threshold is converted into a timeframe based on predictions from different climate models. The darker blue represents the projected average of all the models, the lighter blue covering all climate models, the outer lines provide a range for uncertainty in the models.*

Most studies focus on technical thresholds to determine the success of policies (Kwadijk et al., 2010; Lempert, 2013; Reeder & Ranger, 2011). However, a recent shift can be observed towards social and political thresholds (Hossain, Ludwig, & Leemans, 2018; Riquelme-Solar, Van Slobbe, & Werners, 2015; Werners et al., 2018; Werners et al., 2015). A political turning point is reached when a current management strategy or policy is unsuccessful due to climate change. For instance, in the Dutch Delta Program and the Thames Estuary, political thresholds are used to define what constitutes an acceptable risk for flooding (Werners et al., 2015). These thresholds come from top-down decision-makers on the European and the national scale. Regionally and locally, there is little to no participation for these political threshold values. On the other hand, a social threshold is influenced by social interests, norms, and values.

2.4 Precarious ambiguity in current approaches

The advantage of using DAPP and turning points is that these concepts generate an adaptive plan specifically highlighting what actions need to be taken now to be prepared for the future whilst remaining sufficiently flexible to allow for possible upcoming changes (Haasnoot et al., 2013). In theory, DAPP seems an effective method for establishing widely supported strategies. Examined more closely, studies and management strategies based on adaptation pathways are inherently technofix and top-down (Barnett, Graham, et al., 2014). This stems from an inclination to rigorously lock down and hold on to a limited group of measures to control the uncertainty into feasible, yet too limited, risk estimates and cost-effectiveness analyses (Wise et al., 2014). Employing such a method to climate adaptation pathways possibly overlooks the knowledge and values of people who are not involved in the decision-making process but who are impacted by the choices made (Barnett, Graham, et al., 2014). This is echoed by Wise et al. (2014), who studied various complications arising in current climate adaptation pathway studies and management. They concluded that researchers and decision-makers should concentrate on understanding how values and interests can contribute to desirable adaptation pathways because climate adaptation can not only be empowered but also hindered by the knowledge and values of everyone affected by the decisions made.

To expand on that, in climate adaptation it frequently occurs that goals, visions, knowledge, and values differ between individuals and groups on all scales (Bosomworth & Gaillard, 2019; Wise et al., 2014). Different people have different ways of understanding a problem, other visions of the subject at hand, alternative ways of finding solutions and evaluate results differently because of differences in their values, knowledge, and interests. This is called 'framing', or rather the way people perceive and communicate their 'reality' within their respective frames of reference (Dewulf, Craps, Bouwen, Taillieu, & Pahl-Wostl, 2005). Even in situations where the effects of climate change are relatively certain, i.e. when there is no lack of knowledge or information, there can still be intrinsic conflicts in how different groups of people frame the problem of climate change and the need for adaptation (Van Buuren, Driessen, Teisman, & van Rijswick, 2014). Within environmental management, and for climate change in particular, ambiguity arises when numerous frames of references are employed simultaneously to comprehend the same phenomenon (Dewulf et al., 2005). The ambiguity surrounding climate change results in situations where adaptation pathways are rarely adopted in a context with apparent and unambiguous goals and values (Barnett, Graham, et al., 2014). When an adaptation pathways approach is inherently technofix and top-down and does not consider ambiguity, it becomes challenging to develop adaptation strategies that are both fair and widely supported (Barnett, Graham, et al., 2014).

With turning points being an inherent concept within the adaptation pathways approach, the majority of turning points are either technically or politically determined and overlook the ambiguity (Barnett, Graham, et al., 2014). Ambiguity within turning points is particularly problematic for local communities when decisions are made top-down. Risks viewed as critical on a national level may not be as significant on a local scale or vice-versa (Van Buuren et al., 2014). Setting a political turning point based upon national or regional strategies can be expensive and consequential for local living arrangements. This is particularly precarious when a threshold based on national or regional strategies does not cause the effects viewed as hazardous for the local community (Barnett, Graham, et al., 2014; Werners et al., 2015). Similarly, it is problematic when a threshold is set at a particular value, yet local people already experience difficulties for their living arrangements before the threshold value is reached.

Sharing knowledge and communication between various stakeholders reduces ambiguity in turning points (Bosomworth & Gaillard, 2019). Therefore, a participatory method should determine turning points. To reduce ambiguity, a participatory approach has to include a range of different stakeholders that can contribute equally (Barnett, Graham, et al., 2014; Dewulf et al., 2005). Given that a participatory approach can reduce ambiguity in turning points, it is remarkable that a recent review by Bosomworth and Gaillard (2019) identified that the majority of the studies still tend to lean towards technically determined and top-down approaches. The reason for this is that the identification of a threshold is rarely unanimous due to varying viewpoints on what is perceived as acceptable (Barnett, Graham, et al., 2014; Bosomworth & Gaillard, 2019; Werners et al., 2015). As a result, the process becomes easier when fewer stakeholders are involved, and no participatory approach is adopted. Consequently, a participatory approach does not get enough consideration when determining turning points, which still tend to lean towards top-down and biophysical or political thresholds.

However, some cases did use an experimental approach to identify bottom-up social thresholds, as discussed by Bosomworth and Gaillard (2019). For instance, Jacobs, Boronyak, Mitchell, Vandenberg, and Batten (2018) used risk categories to identify thresholds based on participants' views on unacceptable change related to climatic events. In contrast, Maru, Stafford Smith, Sparrow, Pinho, and Dube (2014) argued that thresholds could only be identified once a threshold is exceeded. Bosomworth et al. (2018) let participants select important critical attributes to identify thresholds. Finally, Barnett, Graham, et al. (2014) drew upon participants' past experience to identify what scenario embodies the limit of acceptability. Provided that these approaches are in the early stages of development, the methods to bottom-up established thresholds warrants further research. For this reason, this study focuses on determining bottom-up established turning points building upon the ideas in the studies mentioned above.

2.5 The landscape of landscape values

By determining social and bottom-up established thresholds, adaptation pathway actions are implemented at a rate relevant for local stakeholders, therefore regulating risks to a local vision. This research assumes, based on previous research (Barnett, Graham, et al., 2014; Bosomworth & Gaillard, 2019; Graham et al., 2013; Werners et al., 2015; Wise et al., 2014), that locals will accept and adopt adaptation measures faster when these measures are implemented once an unacceptable situation is reached. Because climate change is a contested topic for many, a stronger foundation for a threshold builds upon the common beliefs of social characteristics (Barnett, Graham, et al., 2014). To identify the threshold for social turning points concerning climate change-induced drought, the research uses the vision of farmers working in the Mariapeel.

Accordingly, the willingness to adapt and accept adaptation measures depends on the moment the social characteristics vital for farmers' well-being are compromised. The social characteristics of a region, including place attachment, its facilities, the local economy, and the visions for the future, are called 'values' (Graham et al., 2013). The advantage of a values-based approach to adaptation is that it concentrates on what people find important in their lives and where they live (Barnett, Graham, et al., 2014; Graham, Barnett, Fincher, Hurlimann, & Mortreux, 2014). These values are subsequently affected by environmental change. Losses caused by climate change disturb not only geographical characteristics and infrastructure but also affect people's values. An example of this is how the rising sea levels can flood important heritage and cultural locations, affecting such a site's cultural value (Graham et al., 2013). Values as a tool and guide in adaptation planning are divided within the current literature into two categories: landscape values and lived values (Ramm, Graham, White, & Watson, 2017).

Landscape values signify the socio-cultural importance people assign to a specific physical location. For instance, Novaczek et al. (2011) used Geographic Information Systems (GIS) to visualize and demonstrate the socio-cultural values of people linked to a specific place in combination with the threat to sea-level rise in Canada. Not only did their tool assist local policymakers in adaptation planning, but it also gave local people the reassurance that they needed to know that their views and perspectives were respected. Lived values, on the other hand, are defined as "valuations that individuals make, in isolation or as part of a group, about what is important in their lives and the places they live" (Graham et al., 2013, p. 49). Graham et al. (2014) studied lived values of people who are at risk of sea-level rise by asking what they find important about their living environment and the importance they assigned to the lived values. The lived values concept indicates a more extensive set of values associated with daily life, whereas landscape values provide a higher level of accuracy on the kind and importance of attached values (Ramm et al., 2017). This paper uses the concept of landscape values instead of lived values. This choice is based on research that has identified landscape values as a predictor for sustainable behaviour (García-Martín, Plieninger, & Bieling, 2018; Ramm et al., 2017; Raymond, Bieling, Fagerholm, Martin-Lopez, & Plieninger, 2016).

Examined more closely, farmers are landscape stewards, defined by J. Brown and Mitchell (2000) as "the responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage" (p. 70). Recent research by Raymond, Reed, Bieling, Robinson, and Plieninger (2016) looked at whether farmers' landscape stewardship influenced whether or not farmers were willing to adopt sustainable measures for their land. They found that farmers differed in their perception and recognition of the functions that a landscape supplied to the social characteristics important for our well-being. In turn, that perception determined whether or not they were willing to take action. The recognition or appreciation of these functions that form the heart of landscape stewardship are landscape values (García-Martín et al., 2018; Raymond, Bieling, et al., 2016). Hence, landscape values are the underlying factor for the protective instincts and can help anticipate someone's attitude and behaviour towards the environment (Seymour, Curtis, Pannell, Allan, & Roberts, 2010; Van Riper & Kyle, 2014), and their corresponding willingness to take action (García-Martín et al., 2018). Farmers may be more likely to respond to climate changes if their landscape values are impacted. Thus, landscape values underpin a farmer's perceptions regarding her or his responsibility to manage and protect the land, and therefore their preferences and concerns for the speed of implementation of adaptation measures. For this reason, the research uses landscape values to indicate the threshold value for social turning points within adaptation pathway planning rather than lived values.

2.6 Towards a framework for a values-based approach to adaptation

Figure 2.3, positioned at the end of this section, presents the schematic representation of the three concepts to show how landscape values can be an instrument for conceptualising turning points.

The idea behind a landscape values-based approach to establish turning points is that when the importance farmers assign to a specific physical location, i.e. landscape values, degrades because of drought, farmers are prepared to implement and accept adaptation measures. Consequently, the moment an adaptation option loses its function to preserve a value of a location, a social threshold is reached, and new measures should be adopted. For instance, when the nature reserve the Mariapeel harbours recreational values for many individuals, the value should be preserved for as long as possible. The moment the recreational value loses its value due to an increase in drought, it exceeds the social threshold.

The issue with values is that most values are not easily quantified because interpretations of values start to play a role. For instance, in the context of the Mariapeel, an individual may find it unacceptable when a particular drought causes irreversible damage to the peat, impacting their recreational value. Whereas another may find it unacceptable when the trees' leaves get their autumnal colour at the beginning of the summer. Every individual has different interpretations of values. It would be a cumbersome task to consider all these interpretations in a region.

A way to circumvent this issue is asking farmers if they believe, based on their past experiences with drought, whether increased drought will affect the landscape values (Ramm et al., 2017). This way, the research does not have to ask for the value's interpretations of individual farmers because they use their own interpretations for how drought may impact the landscape values. Merely knowing that increased droughts will impact the values is sufficient for establishing thresholds.

By unravelling what landscape values farmers perceive to be negatively affected by increased drought and for which values they are likely to act upon provides the basis for the social thresholds (Figure 2.3.a). The social thresholds can be quantified (Figure 2.3b) by asking farmers at what point, i.e. under what scenario, they are likely to act upon this change because they perceive the impact of drought on their values as unacceptable, as done in the approach by Barnett, Graham, et al. (2014). For instance, a farmer remembers a particular drought year in which several values important to her, say recreational value and economic value, were negatively impacted. The recreational and economic value subsequently provide the social thresholds linked to the particular drought defining the climatic threshold.

Hence, the unacceptable scenarios subsequently provide the foundation for the climatic threshold for the turning points (Figure 2.3.b), herein linked to the social threshold. The results from the turning point analysis can subsequently be used as turning points for adaptation measures (Figure 2.3.c).

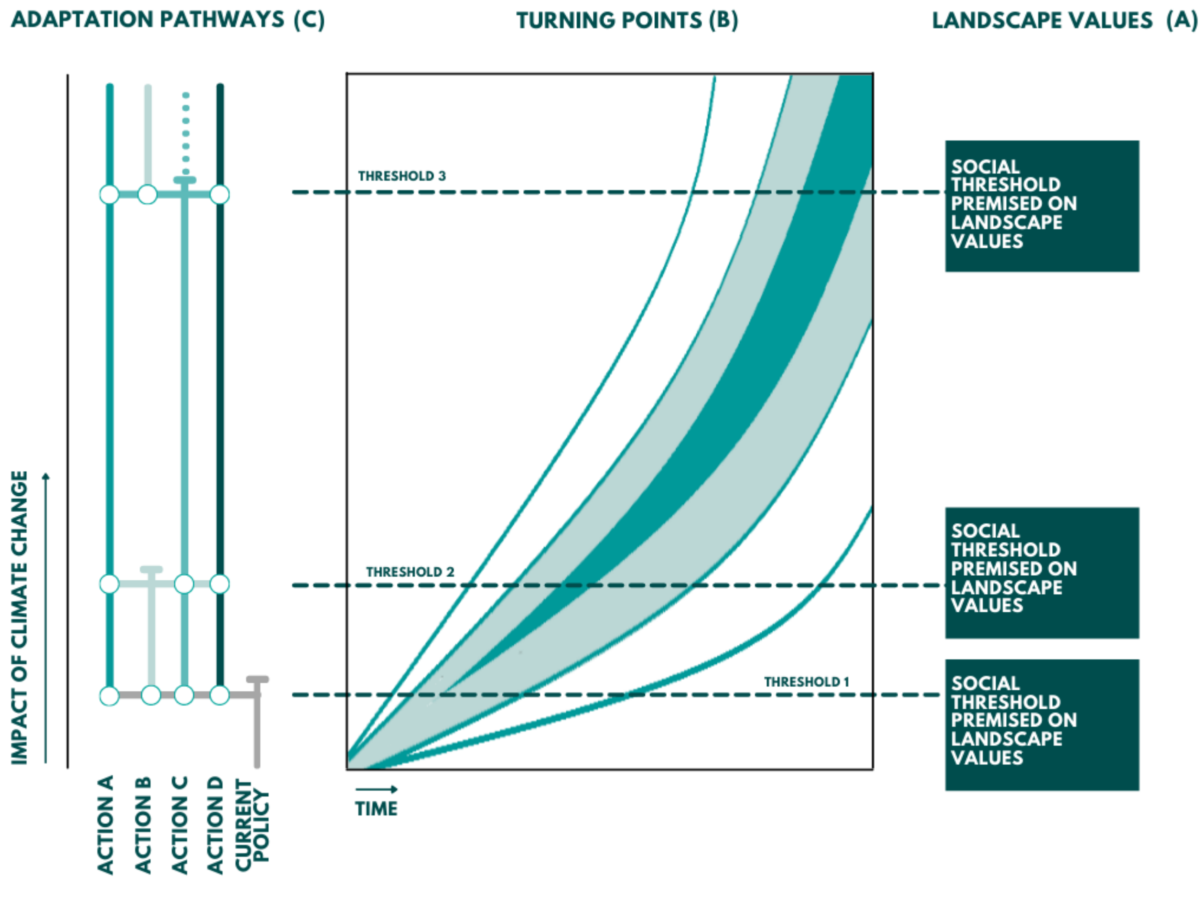

Figure 2.3. A schematic diagram of the three key concepts, derived from Werners et al. (2013), Barnett, Graham, et al. (2014) and (Ramm et al., 2017).

2.7 Applying the framework

The framework, based on a combination of the approaches by Ramm et al. (2017) and Barnett, Graham, et al. (2014), was evaluated by assessing if a values-based approach to turning points is possible for farmers in the Mariapeel. From the previous research background, follows the succeeding research question: *Can landscape values be translated into thresholds for adaptation turning points of farmers in the Mariapeel, Limburg?*

This research question can be split up into five sub-questions, each sub-question a step to answer the main research question:

1. What are the top-rated landscape values for farmers?
2. How do increased droughts in the summer months affect the top-rated landscape values?
3. Which drought scenario constitutes an unacceptable prospective for farmers?
4. For which landscape values are farmers likely to act upon the previously unacceptable drought scenario(s)?
5. Which landscape values of farmers can be translated into thresholds for social turning points?

The proceeding chapter goes further into the methods used in this research. Chapter 4 and Chapter 5 present the results of respectively the landscape values and the climatic data analysis. Chapter 6 assesses the lessons learned along the process and provides recommendations for future research and policy. Finally, the conclusion presented in Chapter 7 answers the main research question.

3 METHODOLOGICAL APPROACH AND METHODS

The next chapter, containing four main components, illustrates how landscape values can determine turning points created by a participatory approach with farmers in the region of the Mariapeel. First, the chapter elaborates on the chosen case study location. Second, the chapter expands on the methodological approach. Third, the chapter provides an overview of the data collection phase. This phase includes the different data collection methods used to answer the sub-questions. Last, the chapter elaborates on the analysis phase. This phase describes how the data collected has been aggregated and analysed.

3.1 Case study

This research is accomplished by focusing on farmers in the region of the Mariapeel in Limburg, the Netherlands. This particular case is highly relevant for the development of bottom-up established turning points for three reasons (Graaf, 2020). Firstly, decisions that affect farmers are often made top-down on a regional or water board level. This limited participatory approach overlooks what is important to farmers, who are not involved in the decision-making process. However, they are affected by the decisions being made because farmers are big water users with long-term interests in the affected regions. Hence, they often have to implement the measures resulting from top-down choices. Therefore, the second reason is that adaptation strategies need to be widely supported by farmers. Lastly, the region itself is a highly relevant case for this research, given that the farmers in this region will play a role in carrying out future adaptation measures, for instance, in the next Water Management Program of 2022-2027. The pressure on the province and the waterboard to introduce these measures is high because the Mariapeel is a protected natural area. As a result, it must comply with the guidelines set by the European Union regarding Nature2000 areas. Therefore, it is highly relevant for the success of a new adaptation strategy to get farmers involved in the adaptation process to generate a larger support base.

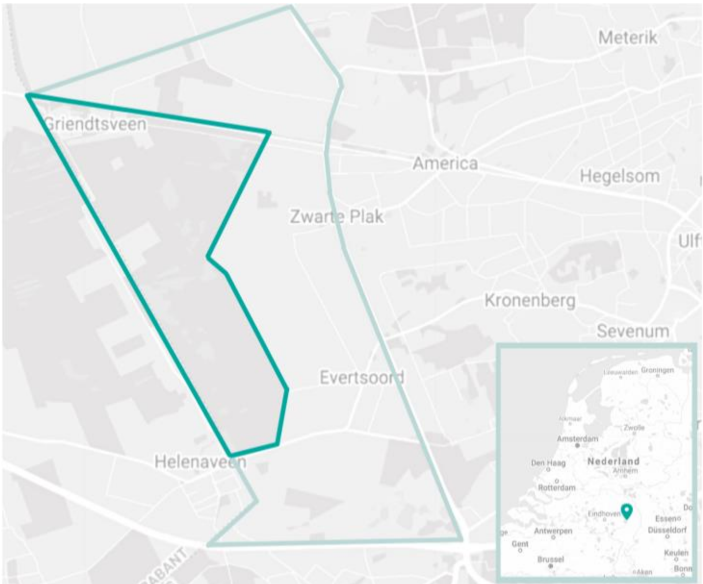

Figure 3.1. *The case study location indicated in mint (mostly farmland) and green (the Nature2000 area the Mariapeel, adapted from Google Maps (Google, n.d.-a, n.d.-b).*

3.2 Methodological approach

Given the nature of the research question, the thesis adopted a qualitative case study approach. A case study approach was applicable given the need to explore one particular phenomenon, landscape values, comprehensively in an everyday context. Therefore, a case study approach was amendable answering more explanatory questions such as ‘what’, ‘why’ and ‘how’. The case study was carried out on a local scale level; this included the nature reserve the Mariapeel and the adjacent agricultural lands. Given that the case facilitates understanding landscape values as turning points, the case study characterizes as instrumental. The primary data was gathered through descriptive research to answer the research questions.

3.3 Data collection phase

Based on previous research, the data collection method can be done by both interviews (Barnett, Graham, et al., 2014) and (questionnaire) surveys (Novaczek et al., 2011; Ramm et al., 2017). Because the concept is complex, given that it deals with beliefs and attitudes, it would have been ideal to collect data in-depth through interviews. However, after consulting with experts in the field, it was decided that the most likely way to get responses was to conduct a survey. The consensus was that farmers are generally less inclined to participate in interviews. Because the lockdown[2] made it inappropriate to travel to the region, the method of choice was online surveys with the option of an additional telephonic interview. Moreover, as can be derived from the approach by Ramm et al. (2017), a survey can provide enough data to answer the research question. Using both a qualitative technique and a quantitative technique increased the internal validity. This is based upon the assumption that when information is gathered through different approaches, it should result in similar findings (Bhattacherjee, 2012).

3.3.1 Questionnaire survey

The survey splits into five different subjects: farmers’ current situation (subject A), the way farmers value their farm (subject B), the way farmers value the nature area the Mariapeel (subject C), droughts (subject D), and the round-up (subject E). Table 3.1. goes into detail how the different subjects and survey questions contribute to answering the sub-questions. Annex A provides a detailed explanation of the survey and the operalization of the questions.

Table 3.1. *Sub-questions and corresponding subject and questions in the survey.*

Sub-questions		Subject	Relevant survey questions
1	What are the top-rated landscape values for farmers?	B, C	5, 6, 8, 9, 10
2	How do increased droughts in the summer months affect the top-rated landscape values?	D	11, 12, 13

[2] The data collection phase took place between the 8th of December and the 1st of February. The ‘hard’ lockdown instructed by the government of the Netherlands started the 14th of December and laster several months thereafter. Between this period it was strongly discouraged to travel, both domestically and abroad.

3	Which drought scenario constitutes an unacceptable prospective for farmers?	D	14
4.	For which landscape values are farmers likely to act upon the previously unacceptable drought scenario(s)?	D	16, 17, 18, 19

When designing the survey, particular emphasis was put on the following considerations to address the drawbacks and biases of surveys as much as possible (Bhattacherjee, 2012). Negatively phrased questions were avoided wherever possible. The questions were worded in 'simple' Dutch to be easy to understand. Special attention was given to prevent ambiguous, biased language. Double-direct questions were rewritten, and respondents were given enough information without promoting response bias. Moreover, specific care was taken to question sequencing. The easy and non-threatening questions, such as age, gender, and occupation, are placed at the beginning of the survey. When changing to another subject, the participants could see a clear transition. Within this transition, information was provided to the respondents to answer the subsequent survey questions (Annex A, textbox with a green outline). Moreover, several contingency questions are incorporated into the survey to avoid asking participants questions that do not apply to their situation. In addition, given that a drawback of surveys is the low validity rate, many questions were followed by open-ended questions to allow farmers to elaborate on their answers. Finally, more extensive surveys often result in a lower response rate. Therefore, the purpose was to design a questionnaire that can be responded to within 20 minutes. To do so, a conscious choice was made to focus on farmers values regarding their land, and to a lesser extent, the values they harbour towards the nature area the Mariapeel. It is, therefore, harder to draw conclusions on thresholds for the Mariapeel. However, it is still interesting to look at values farmers harbour for the Mariapeel because it provides a good impression of the values involved in the region (Raymond, Bieling, et al., 2016). Hence, to give the full picture, it was necessary to keep the Mariapeel in the assessment.

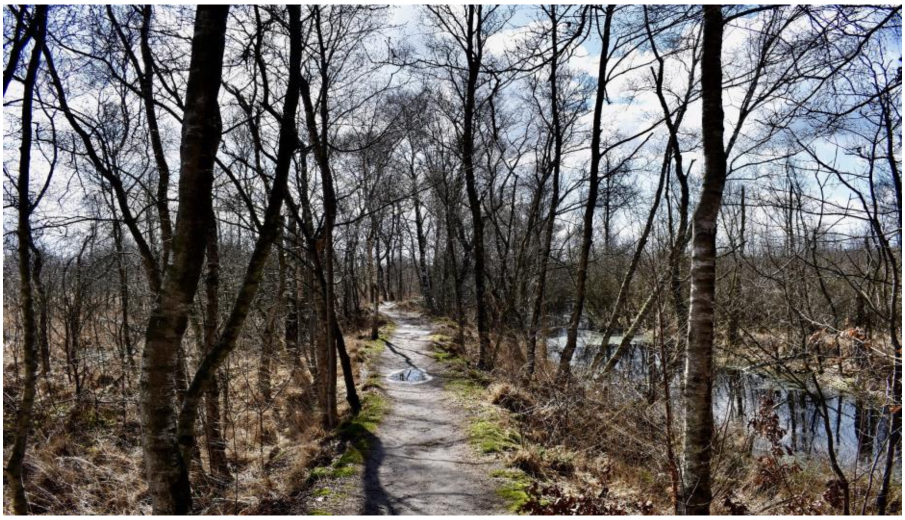

Figure 3.2. *The Nature2000 area the Mariapeel (Harleman, 2021).*

The survey questions are primarily founded upon the interview and survey questions posed by Barnett, Graham, et al. (2014) and Ramm et al. (2017) in their research. Because surveys are the main data collection method, the survey questions were posed so that they would generate the same answers as if the questions were asked in an interview. The survey comprised 16 questions in total. There were eight multiple-choice questions, four open-ended text questions, and four Likert scale questions. When designing the survey questions, special care was put into the content of the questions. Because the surveys needed to be relevant for farmers, the landscape values posed by Ramm et al. (2017) and the scenarios described by Barnett, Fincher, Hurlimann, Graham, and Mortreux (2014) could not be blindly copy-pasted. The following paragraphs describe how the landscape values were altered. In addition, the rationale behind the scenarios is described in the sub-section thereafter.

3.3.1.1Landscape values

The landscape values in this research are tailored to a preliminary literature review on landscape values for farmers. The review can be found in Annex B. The definitions of the landscape values were translated and worded differently in order to facilitate an easier understanding of each value's definition. The changes made to the translation can also be found in Annex B. Table 3.2 presents the final definitions of the landscape values.

Table 3.2. *Names and definition of the landscape values used in the survey.*

Landscape value	Definition in the survey
Aesthetic	I value this place for the beautiful scenery, sights, sounds and smells
Biodiversity	I value this place for the variety and abundance of birds/animals/plants
Cultural-historical	I value this place for passing on wisdom, knowledge and traditions (cultural-historical)
Economic	I value this place because it supports myself and/or my family and loved ones
Future	I value this place because it provides sustainable land management for future generations of farmers
Identity	I value this place for the lifestyle and lifestyle of a farmer
Social Relations	I value this place for the feeling of belonging to the environment and/or the community
Learning	I value this place for being able to learn from the environment
Life-sustaining	I value this place for producing local and/or good quality food
Recreation	I value this place our leisure time here
Religious/spiritual	I value this place for the sacred, religious or profound experience
Therapeutic	I value this place for the stress reduction, comfort and/or rest
(Access)	I value this place because everyone has access to the nature reserve, free of restrictions (only visible for the Mariapeel question)

3.3.1.2 Climate scenarios

Because values are difficult to translate into quantifiable thresholds, an additional part of the survey asked a set of questions about possible scenarios on drought, based on the study by Ramm et al. (2017) and Barnett, Fincher, et al. (2014). To ensure the relevance and tangibility for the participants, the climate scenarios were based upon two dry years in recent history, 2003 and 2018. The reason for choosing these two years is that most farmers will have consciously experienced these dry years. Therefore, they could judge for themselves whether they found the scenario acceptable or not. The scenarios presented to the farmers can be found in Table 3.3.

Table 3.3. *Recurrence time of precipitation deficits, as adopted from Sluijter et al. (2018).*

Year	Recurrence time
2003	Every 2 years
2003	Every 3 years
2003	Every 8 years
2018	Every 10 years
2018	Every 15 years
2018	Every 25 years
None of the above	-
Other	-

3.3.1.3 Sampling the data

The farmers were selected based on a sampling method called 'snowballing'. The method is built upon the idea that an initial recruit can recruit several other recruits interested in the research and so on (Zach, 2020). Because the survey was anonymous, it was not possible to see how the survey was distributed amongst farmers. Ultimately, 15 farmers filled in the anonymous questionnaire and were included in the analysis.

The unit of analysis of this research is the landscape values of individual farmers. Accordingly, the purpose of the research was not to make generalizations. Therefore, data saturation is not as important, and the small sample does not detract from the results' validity. Trends are discussed with more caution.

3.3.2 Interviews

The main shortcoming within surveys is that the researcher is limited in understanding the participants' responses, making a questionnaire an inadequate method to analyze the significance and rationale behind a respondent's answers. While the survey responses provide the data to answer the research questions, the interviews were used to gain a deeper understanding of what farmers find important in their everyday lives and the environment. The chosen interview method is semi-structured interviews because they give the interviewee a chance to communicate their beliefs in their own way.

The interview guide (Annex C) is largely derived from Ramm et al. (2017) and Barnett, Graham, et al. (2014). The questions differ because values are not mentioned in the questions. The reason for not directly asking about landscape values, but asking what farmers find important, is that it was expected that not many know what landscape values are. In addition, the interviews were conducted by telephone. While a list of landscape values and definitions can be brought to an interview face-to-face, this is not possible for an interview by telephone. The concept 'landscape values' was therefore purposely emitted from the interview. The reasoning behind conducting the interviews by telephone was two-fold. First, because of the COVID-19 lockdown, it was irresponsible to conduct interviews face-to-face. Second, given that their profession does not resort to video conferencing platforms as much as other professions, it was easier for the interviewees to telephone than to conduct an interview via platforms such as Zoom, Skype or Teams. Eventually, three farmers were interviewed (Annex C). The interviews were recorded with the consent of the interviewee.

3.4 Analysis phase

3.4.1 Survey analysis

The majority of the results are based on the survey data. How to analyse the survey results depended on the data type of that question (Peters, 2015). Three main data types were used within this research: nominal data, ordinal data, and ratio data (Appendix B, Table B.1). Because of the small sample and the absence of a set measure of distance between the answers, all data were analysed by relative frequency statistics and further visualized in contingency tables or bar charts.

The open-ended questions asking for clarification on the provided answer are elaborated upon in the interview sections of the results, coded in the same way as the interviews. The open-ended questions asking whether there were other values or scenarios not included in the questions are incorporated in the survey results.

3.4.2 Interview analysis

The interviews are analysed by thematic analysis. The code log can be found in Annex D. In here, all the coding process choices are indexed. Coding families were created after the coding process.

3.4.3 Climatic threshold analysis

The threshold values identified in the survey had to be translated into climatic thresholds on a time scale. The scenarios that were presented to the farmers were tailored explicitly to drought scenarios as provided by the KNMI (Sluijter et al., 2018). The KNMI measures drought as a physical process identified by the meteorological indicator precipitation deficit. A precipitation deficit is calculated by subtracting evapotranspiration from precipitation. The KNMI uses the mathematical formula of Makkink for calculating evapotranspiration. For this reason, the Makkink method was used instead of the Penman-Monteith method, as recommended by the Food and Agriculture Organisation (FAO).

3.4.3.1 Climate data

The data is simulated by The Inter-sectoral Impact Model Intercomparison Project (ISIMIP), accessed from the Water Systems and Global Change Chair Group. The grid cells of the study location (latitude: 51.40; longitude: 5.96) were extracted from the NetCDF file in RStudio. The data was subsequently analysed in RStudio. The data contains five ISIMIP climate models (gfdl-em2m, hadgem2-es, ipsl-cm5a-lr, noresm1-m, miroc-esm-chem. The difference between the models results from a divergent range of climatic variables, processes and parameters (Flato et al., 2014). In this research, the timescale ranges from 2020 to 2100. Aside from the five climatic models, two Representative Concentration Pathways (RCPs) were used (RCP4.5, RCP8.5). It was decided to assess both a lower-range (RCP4.5) and an upper-range (RCP8.5) scenario because this resulted in a bandwidth in which a turning point can occur.

3.4.3.2 The calculation

To derive the Makkink evapotranspiration, daily average temperature and shortwave radiation are needed (Schuurmans & Droogers, 2010). The Makkink method for evapotranspiration, as used by the KNMI, is presented below in Equation 1 (KNMI, 2005).

$$Er = \frac{1000 \times 0.65 \times \delta(T)}{\{\delta(T) + \gamma(T)\} \times \rho \times \lambda(T)} \times Q \ [mm/etm] \qquad \text{[Eq. 1]}$$

With:

Er Reference crop evapotranspiration $[mm/etm]$
δ Vapour pressure gradient in relation to water $[hPa/°C]$
Q Solar radiation $[J/m^3]$
γ Psychrometric constant $[hPa/°C]$
ρ Density of liquid water $[kg/m^3]$
λ Latent heat of vaporisation $[J/kg]$
T Average temperature $[°C]$

$$[C]Es\ (T) = 6.107 \ \times 10^{7.5 \times \frac{T}{(237.3+T)}} \ [hPa] \qquad \text{[Eq. 2]}$$

Es Vapour pressure in relation to water

$$\delta(T) = \frac{7.5 \ \times 237.3}{(237.3 + T)^2} \times \ln 10 \times Es(T) \ [hPa/°C] \qquad \text{[Eq. 3]}$$

$$\gamma\ (T) = 0.646 + 0.0006 \ \times T \ [hPa/°C] \qquad \text{[Eq. 4]}$$

$$\lambda(T) = 1000 \ \times (2501 - 2.38 \ \times T) \ [J/kg] \qquad \text{[Eq. 5]}$$

$$\rho = 1000 \ [kg/m^3] \qquad \text{[Eq. 6]}$$

All analyses are performed on the summer months of June, July and August. Because a precipitation deficit is commonly calculated as a total of several months, the variables for every month are aggregated over the whole summer. Given the large variance between the climate models, a linear trendline of the mean of the models visualizes the general trend of the deficit. The reason for not incorporating the average of the five climate models is that by calculating and subsequently visualizing the mean, the variation between the models is lost. By visualizing the mean of the models instead of displaying the climate models, the line would give a much more moderate result because it filters out the extremes. For this reason, the mean of the models is not visualized in the figures. Yet the mean does still indicate a general trend. The climatic thresholds of 2003 and 2018 were determined by accessing the historical daily average temperature, shortwave radiation and precipitation. The evapotranspiration was consequently calculated, and the precipitation deficit for the summer of 2003 and the summer of 2018 was obtained from these calculations. This was consecutively a 194.5mm and 221.8mm deficit.

4. RESULTS: LANDSCAPE VALUES AS A BASIS FOR SOCIAL THRESHOLDS

The following chapter focuses on the questionnaire survey results and the interviews with farmers working in the area adjacent to the Mariapeel. The purpose of this chapter is to determine which values farmers believe are negatively impacted by increased drought and at what point they are willing to act on these values. Eventually, this results in socially relevant thresholds, as visualized in the framework (Figure 2.3.a). The chapter sections are divided based on the first four sub-questions posed in this research. The chapter identifies what landscape values are important, which scenarios constitute unacceptable, the perceived risk to landscape values, and the landscape values that signify action for countermeasures. Each section subsequently splits up in two, one part focuses on the survey responses, and the other part concentrates on the interviews. Every section ends with a conclusion, answering the sub-question. Chapter 5, the chapter hereafter, focuses on translating social thresholds into climatic thresholds for turning points.

4.1 Respondent characteristics

4.1.1 Survey respondent characteristics

Table 4.1 gives an overview of farmers' attributes who completed the survey.

Table 4.1. *Respondent attributes of farmers working the area around the Mariapeel.*

Category	Subcategory	Count (N = 15)	Percentage
Sex	Female	1	7%
	Male	14	93%
	Other		
Age	18 – 24		
	25 – 34	1	7%
	35 – 44		
	45 – 54	5	33%
	55 – 64	6	40%
	65 – 74	3	20%
	75 – 84		
	85 and older		
Agricultural activity	Arable farming	3	20%
	Horticulture in the field	1	7%
	Horticulture in the greenhouse	1	7%
	Animal husbandry	11	73%
Property rights	Owner	15	100%
	Tenant		
Familiar with Mariapeel	Yes	15	100%
	No		
Drought damage experience	Yes	15	100%
	No		

4.1.2. Interview respondent characteristics

The interviewed farmers are livestock farmers, owners of the company they took over from their parents, and have lived in the area for (almost) all of their lives. Annex C provides the list of names of the farmers.

4.2 What are the top-rated landscape values for farmers?

The first step in the research is to determine what is important for farmers based on landscape values (survey) and interests (interview) for their property and the Nature2000 area the Mariapeel. The purpose of these questions was to have farmers think about their property and the environment from a values perspective. It provides the basis for the next questions on perceived risk and additional measures.

4.2.1 Landscape values for farmers' property

4.2.1.2. Survey

Farmers rated a list of landscape values according to how important they perceive their property values. The figure below displays the Likert scale graph, the colour scheme represents the ordinal sequence from 'not at all important' to 'very important', visualized from red to blue.

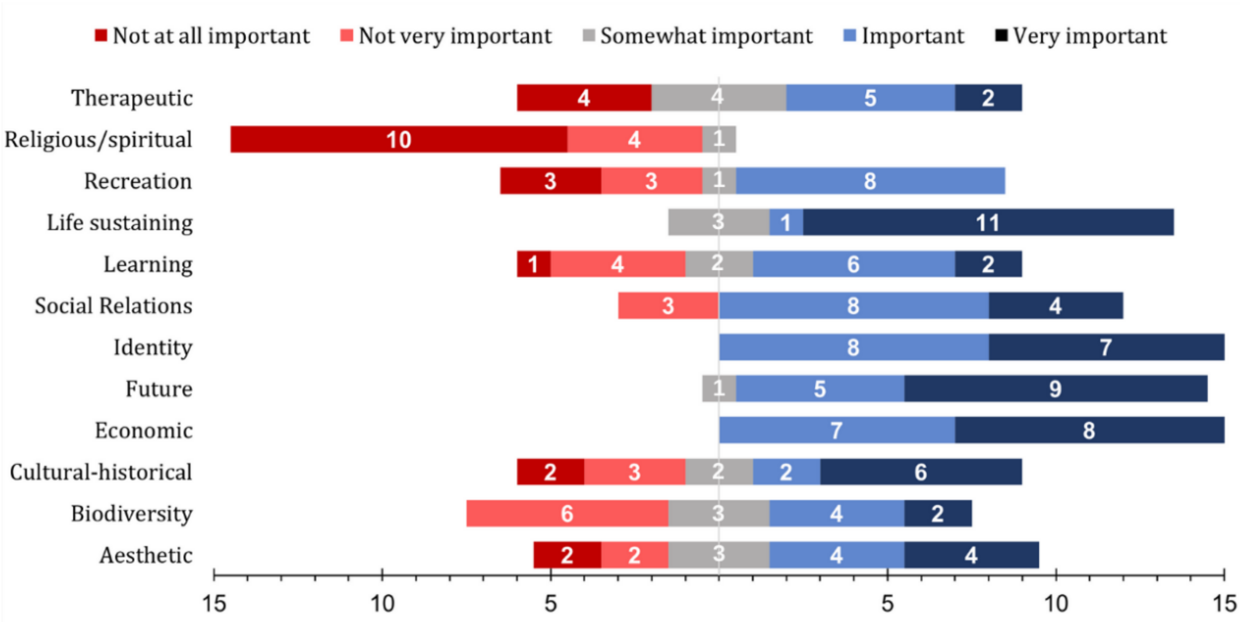

Figure 4.1. *Landscape values for farmers' property are plotted against how often a value is rated on an importance category. The data labels in white denote source data.*

What immediately stands out is that most values skew to the spectrum's positive side. As evident in Figure 4.1, the most important values are life-sustaining, identity, future, and economic, whereby life-sustaining is regarded most often as 'very important'. Except for three respondents, most farmers did consider social relations an important landscape value. The most considerable difference between farmers, one can find in the landscape values aesthetic, biodiversity, cultural-historical, learning, recreation, and therapeutic. In contrast to the important rated values, the values aesthetic, biodiversity, cultural-historical, learning, recreation, and therapeutic have less to do with farming and being a farmer and more with personal preferences. The values to do with agriculture generally rate as more important. In addition to the standard list of values, farmers expressed several values in a non-structured question asking for additional landscape values. Four farmers mentioned the intricate but complicated balance between farming and nature. Three farmers pointed out the difficulty of managing a company within the current legislative environment.

4.2.1.2 Comparison with interviews

The most frequently mentioned interests [in Dutch: *belangen*] of farmers during the interviews are that they should be able to conduct their work as a farmer without too many restrictions to earn a decent living. One farmer mentioned: "I find it important that we are seen as fully-fledged entrepreneurs". The quality of the farm, the ground, and the animals are also significant for all farmers. Being able to enjoy their work and having the opportunity to do so in the future is referred to twice.

Considering how these interests correspond to the survey's landscape values, one may observe that the following landscape values somewhat resemble the interests mentioned here. The values rated as most important in the survey, economic, future, identity, and life-sustaining, are also reflected in the interviews. The economic value refers to the interest in earning a decent living. The future value resembles the interest of doing business in the future. The identity value corresponds to being able to enjoy the work they do. Lastly, the life-sustaining value reflects the interest in taking good care of the farm, the ground, and the animals.

What also stands out in the survey is the importance of the relationship between farmers and nature. This relationship became particularly evident in the interviews. The farmers explain an intricate but complicated balance between farmers and nature. With the Nature2000 area close by, they are affected by strict regulations where multiple stakeholders are involved. One farmer mentioned how "it is important that nature and agriculture can work together, we should not experience any inconvenience from nature, and nature not from us". Another farmer endorses this: "together you come farthest, by keeping in mind each other's interests".

In addition, three farmers pointed in the survey towards the difficulties managing a company in the current legislation. While not so much of a value, this does indicate the tension between the farmers and the water authorities. In the interviews, the farmers' expressed their concern about the ban on irrigation of surface water in dry months, which is necessary to avoid buying cattle feed elsewhere. Another worry is the potential ban on groundwater irrigation.

Figure 4.2. *Farmland adjacent to the Mariapeel (Harleman, 2021).*

4.2.2. Landscape values for the nature reserve the Mariapeel

4.2.2.1. Survey

Farmers were also asked to rate the adjacent nature reserve's landscape values. Whereas farmers work on their property adjacent to the reserve every day, this does not imply that farmers visit the Mariapeel as often. Therefore, respondents had to answer how frequently they visited the Mariapeel itself. Figure 4.3 displays the results.

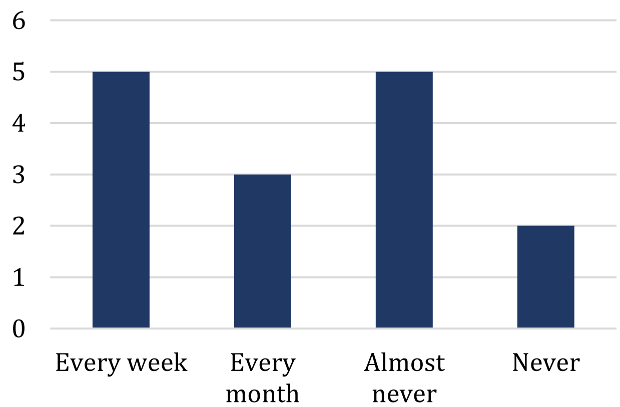

Figure 4.3. A visual representation of how often farmers visit the Mariapeel for leisure activities.

Even though all farmers know of the reserve, not all farmers make as much use of the reserve for recreational purposes. As shown in the figure, visitation is fairly distributed amongst the respondents. Half of the respondents visit rather frequently, whilst the other half rarely visits.

After establishing knowledge of the area, the survey asked the farmers to rate the landscape values they harbour for the nature reserve. Figure 4.4 displays the results in a Likert scale graph.

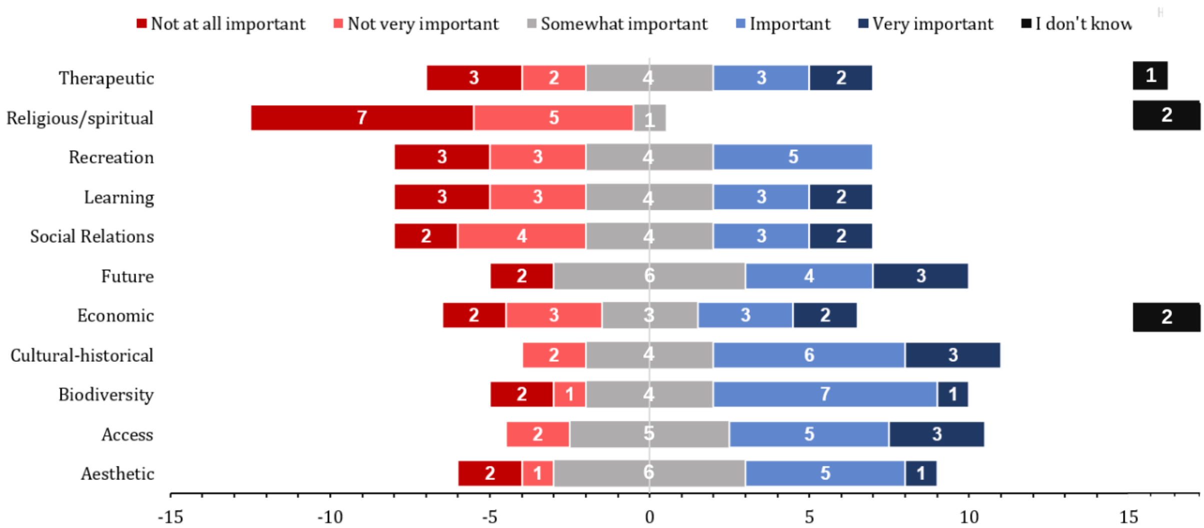

Figure 4.4. Landscape values for the Mariapeel plotted against how often a value is rated on an importance category.

What becomes clear from Figure 4.4 is that no value proportionately stands out. The results are much more moderate compared to the landscape values for the farmers' property. The graph displays a more moderate spectrum of importance for the landscape values of the Mariapeel, indicated by a more considerable middle ground importance. For almost just as many farmers who rate a value as 'important', others filled out 'not important'. The extremes of 'not at all important' and 'very important' are reported respectively more often and less frequently than the values for farmer's property. Moreover, other values appear to play a more prominent role, such as cultural-historic, access, and biodiversity. This makes sense given that the landscape values for farm property have a different meaning than values for a nature reserve, mainly when not frequently visited. Besides, a farm is used for occupational purposes, while the nature reserve is used for recreational purposes. This explains the difference in the priority given to the different values. Even if someone never or rarely visits the nature reserve, one can still find it essential that everyone has access to the reserve. However, the farmer may give less weight to the reserve's recreational, aesthetic, and learning value because the farmer rarely visits. This possible relation shows in Table 4.2 presented below. The other way around is also valid. If the farmer uses the nature reserve a lot, it is only logical that she or he finds the recreational value more important.

Table 4.2. Pivot table for recreational value compared to the number of times visiting the nature area.

		Recreational value			
		Not at all important	Not important	Somewhat important	Important
Number of visits	Never	2			
	Rarely	1	2	2	
	Every month		1		2
	Every week			2	3

4.2.2.2. Comparison with interviews
The most frequently mentioned interest of the farmers regarding the Mariapeel is that they find it important that the area is conserved for future generations. However, the opinions differ on how the natural area should be conserved. One farmer mentioned that "if the farmers would get enough water to keep their lands healthy, the adjacent natural reserve would automatically profit". Another farmer pointed out that he did not mind the natural area in the region but was asking himself, "to what extent, and to what cost, you can keep the Mariapeel artificially alive, and who should bear the costs of this?". One farmer mentioned the importance of the area for local recreation and tourism. He attached much value to the aesthetic beauty of the area and that people should enjoy it, whether they are locals or tourists.

Considering how these interests correspond to the survey's landscape values, the following landscape values somewhat resemble the interests mentioned in the interviews: namely, the aesthetic, future, and recreational value of the area. The future value corresponds to the interests in nature conservation, the recreational and aesthetic value link to the interests of tourism and recreation of the nature reserve. The additional value of the relationship between nature and agriculture comes back when farmers mentioned at what cost the reserve should be conserved.

4.2.3. Conclusion

This section aimed to unravel what farmers find important, and from the previous analysis follows that the distribution of values for farmers' property skew positively. In contrast, the values for the Mariapeel are considerably more moderately distributed. The key values for farmers' property are economic, future, identity, and life-sustaining. This is backed up by the interests indicated as important during the interviews. An important additional value is the relationship between nature and agriculture. It is not possible to extract distinguished key values from the analysis of landscape values for the Mariapeel. For almost just as many farmers who rate a value as 'important', others filled out 'not important'. The interests of the interviews also show the discrepancy in values. The number of times the farmer visits the nature area may be related to the broad array of importance. A specific outcome, for this reason, is that there are apparent tensions between nature, agriculture and the authorities.

4.3. How do increased droughts in the summer months affect the landscape values?

A threshold is reached when an action can no longer meet a social objective, in this case, landscape values, due to an increase in drought. Before the objective can be set, it was necessary to understand whether an increase in droughts also has a distinct impact on landscape values. Because values are subjective and mean something different for every individual, this question asked farmers if they perceive the values to be impacted based on their own experiences.

4.3.3. Perceived impact

As shown in Table 4.1, all farmers have had drought damage experience. The interviewees echo this, pointing to the last three summers as particularly problematic. Farmers were asked in the survey to assess how big they perceive the risk of drought for the given list of landscape values for their property, irrespective of whether they find the value important. Figure 4.5 displays variance in a Likert scale graph. The colour scheme represents the ordinal sequence from not probable to very probable, visualized respectively from red to blue.

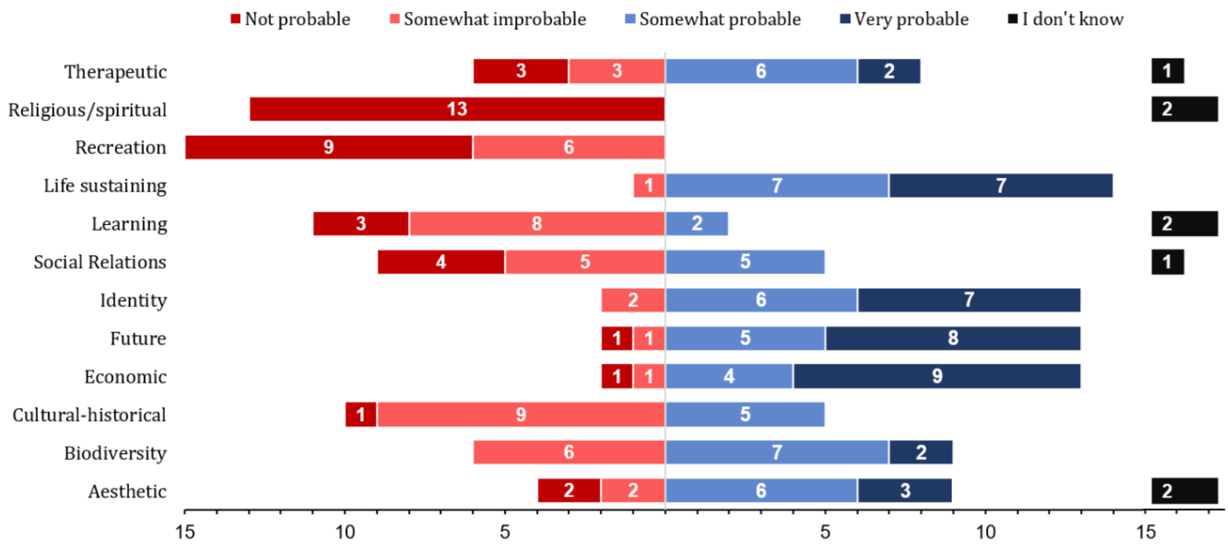

Figure 4.5. Landscape values for farmers' property plotted against the perceived probability that an increase in droughts negatively impacts a value.

As shown in the figure, several values are considered to be either very or at least somewhat impacted by increased droughts. These include the values economic, future, identity, and life-sustaining. On the other side of the spectrum, the values recreation, learning, cultural-historic, social relations, and religious/spiritual stand out as very improbably perceived to be affected by droughts.

The graph shows that two farmers are the exception in not perceiving droughts as a threat to their life-sustaining, identity, future, and economic values. Farmers almost unanimously agree that their religious/spiritual and recreation values will not change with increased droughts. There is still quite a lot of variation between farmers. Farmers are still very much divided on the therapeutic, cultural-historical, biodiversity, and aesthetic values. It could be that farmers filled out this question with each value's previously rated importance in mind. For instance, if a farmer does not believe a cultural-historical value is important to the farm, there is little to be impacted. In much the same way, it is noteworthy that several values rated as relatively important in Figure 4.1 (recreation, learning, social relations, and cultural-historical) are not necessarily perceived as threatened by increased droughts.

4.3.4. Comparison with interviews

The interviews asked farmers what problems they encounter during these dry periods. All farmers mention that droughts like those we have had in the past three summers are incredibly tiresome and very costly. It is tiresome because irrigation during droughts takes up a lot of time and energy. In addition, the farmers point out that it impacts their mental health. Droughts are not only physically demanding but are causing significant worry, such as whether they will have enough revenues, along with a decline in job satisfaction. Farmers also mention their concern about the increasing pressure of restrictions on irrigation. Two farmers talked about producing good quality food for their cattle, which became difficult during dry periods, particularly with the restrictions imposed by the regional water authority.

Bearing in mind how these interests correspond to the survey's landscape values, some values somewhat resemble the interests mentioned here. The economic value is mentioned with the increasing costs of irrigation and earning a decent income. Job satisfaction diminishes because of additional worry during those dry periods, which resembles the identity value. When farmers talk about producing good-quality food, they mentioned the life-sustaining value.

4.3.5. Conclusion

Values are subjective. Therefore, they cannot be quantified. A social threshold can be based on a social non-quantifiable objective, but ultimately the aim is to generate quantifiable turning points. Hence, the analysis on whether an increase in droughts also has a distinct impact on landscape values, based on farmers' interpretations. From the assessment in Chapter 4.3 follows that increased drought has apparent impacts on the economic value, the future value, the identity value, and the life-sustaining value. The interests in the interviews are in line with these values because an increase in droughts diminishes their earnings, job satisfaction, and the quality of the food produced. At what point these landscape values are negatively affected, and action is required according to the farmers depends on which drought increase they deem unacceptable (Chapter 4.4) and for which values farmers are willing to act (Chapter 4.5).

4.4. Which increased drought scenario constitutes an unacceptable perspective for farmers?

Figure 4.6 displays all scenarios respondents regard as unacceptable. Here, the survey asked farmers to consider the precipitation deficit scenarios of the summers of 2003 and 2018.

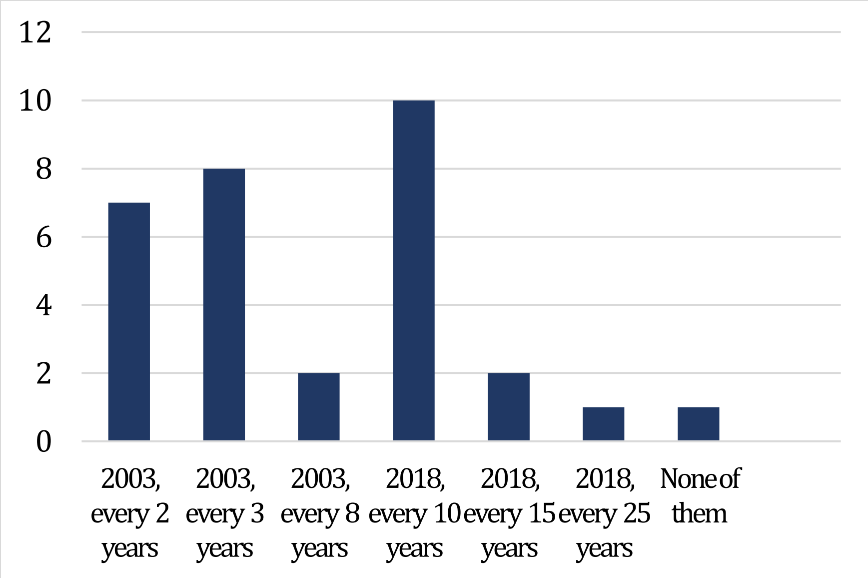

Figure 4.6. *The number of times respondents rule a scenario as unacceptable.*

As demonstrated in the figure, both the more frequent occurrence of the 2003 scenario and the 2018 scenario are considered unacceptable. It occurred merely once that a farmer specified a different scenario. This farmer mentioned that every drought constitutes unacceptable if that means negative consequences for the company. Each scenario, therefore, received one additional vote. Once, a farmer did not consider any of the scenarios unacceptable. In the interviews, all farmers mentioned that an increase in dry periods similar to the summers of 2018, 2019, and 2020 would be highly problematic. Counterintuitively, not all farmers who deemed the scenario '2003, every three years' unacceptable also ticked the scenario '2003, every two years'. It is assumed in this research that the farmers who only ticked on the former scenario did so, specifying a minimum baseline of acceptability. Therefore, in the analysis, it is presumed that when a farmer filled out the scenario '2003, every three years', they also consider the scenario '2003, every two years' unacceptable.

4.4.2. Conclusion

The farmers chose all scenarios at least once as an unacceptable scenario. '2018 every ten years', '2003 every three years' and '2003 every two years are selected most frequently. For this research, it means that the climatic threshold analysis in Chapter 5 includes all the scenarios.

4.5. For which landscape values are farmers likely to act upon the previously unacceptable drought scenario(s)?

Now we know what scenarios farmers deem unacceptable and which values are perceivably impacted during these events. To translate this information into social thresholds, this step discerns for which values farmers would consider additional measures to prevent the consequences of an unacceptable scenario for the landscape values.

4.5.1. Survey

The survey asked farmers which landscape values contribute to the decision taken in the previously selected drought scenarios. Figure 4.7 presents the results.

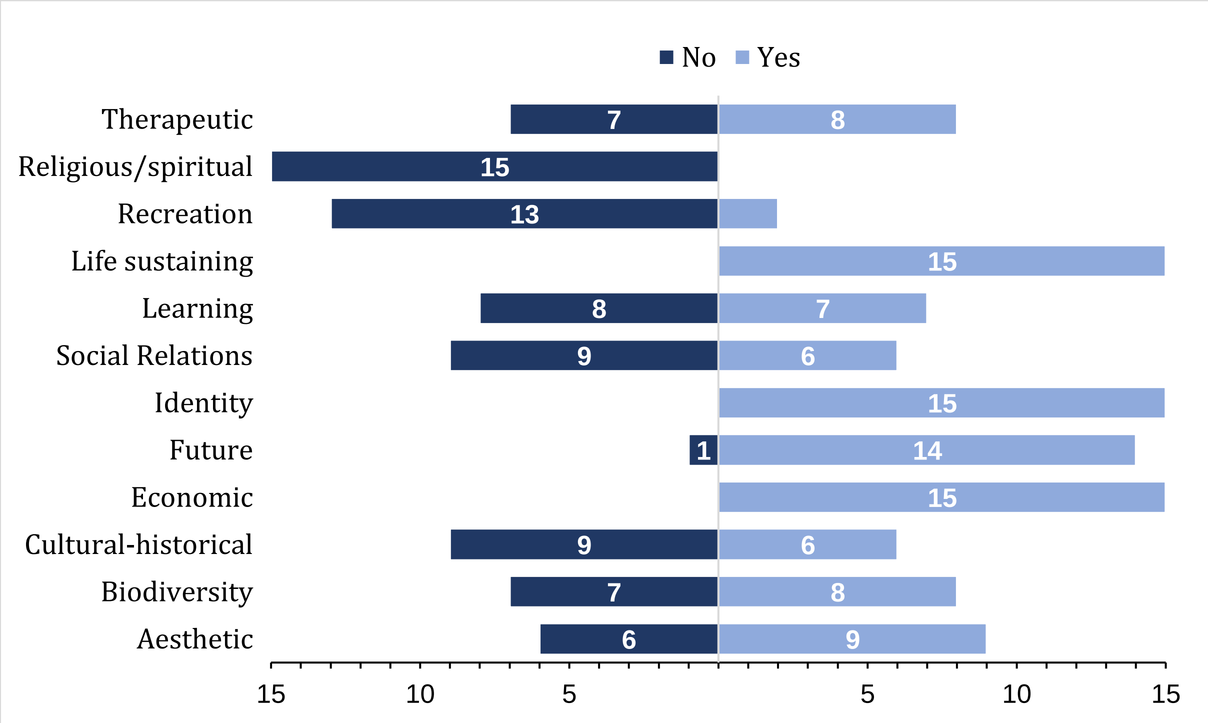

Figure 4.7. Landscape values for farmers' property plotted against the number of times they would take additional measures to prevent the consequences of drought related to the unacceptable scenarios.

What can be seen in the Likert graph is that farmers are almost always inclined to take additional measures if the following values are negatively affected: life-sustaining, identity, future, and economic. The farmers differentiate for the values therapeutic, learning, social relations, cultural-historical, biodiversity, and aesthetic. The religious/spiritual and the recreational value almost unanimously do not constitute a spur to action. What is noteworthy is that, for instance, the social relations value rates important in Figure 4.1. Yet when it comes to taking action, the farmer is not likely to do so.

The survey asked for some additional remarks on why farmers answered the way they did. Several answers are given. The comments mainly involve how farmers' decision to action is almost always based on the company's prospects and the family. If the measure is affordable, feasible, and prevents damage from drought, they would take (additional) action. Another recurring comment is the importance of job satisfaction.

4.5.2. Comparison with interviews

The previous remarks are in line with what is said during the interviews. The farmers would take measures if what is important to them is impacted. In the interviews, two farmers specified that they did not want to take additional steps if the nature reserve did not implement all previously agreed measures.

4.5.3. Conclusion

This section aimed to translate landscape values into social thresholds. Farmers are likely to act when different drought scenarios impact the economic value, the life-sustaining value, the future value, and the identity value. Thus, from this analysis is gathered that an unacceptable situation occurs during all summer scenarios because these values have deteriorated to such an extent that change becomes essential.

5. CLIMATIC THRESHOLDS AS A BASIS FOR VALUES-BASED TURNING POINTS

The previous chapter explored which values farmers believe are negatively affected by increased drought and that they are willing to act upon some of these values. The question that remains is when this moment occurs, as visualized in the framework (Figure 2.3.b). This chapter aims to provide an answer to the final sub-question, "which landscape values of farmers can be translated into thresholds for social turning points?". Two steps have been taken to answer this question. The chapter correspondingly divides into two sections. The first section examines when the thresholds are exceeded based on trends in meteorological variables. The section hereafter presents the turning point analysis in compliance with what is found in the threshold analysis. The conclusion provides an answer to the sub-question.

5.1 A threshold analysis based on a precipitation deficit

The farmers chose all weather scenarios at least once as an unacceptable scenario. Because the KNMI defines drought as precipitation subtracted by evapotranspiration, the research assessed the following meteorological variables: temperature, precipitation, and shortwave radiation. Annex E shows the development of these variables. The figures in Annex E give a better perspective on how the meteorological variables related to a precipitation deficit will develop over time. Despite the substantial variance between the models, particularly under RCP8.5, the models predict a clear trend upward (temperature and shortwave radiation) and downward (precipitation). The purpose of the next section is to combine the aforementioned meteorological variables and compare the precipitation deficit to the thresholds identified in Chapter 4.4. The linear of the mean is incorporated to clearly indicate either an upward, downward, or stable trend. In addition to the average linear trendline, the model's trendline is shown to compare both trendlines. As seen in Figure 5.1 and 5.2, the 2003 and 2018 threshold scenarios are visualised, indicated respectively by an aquamarine and a black line. The models are split up for visibility purposes. Annex E contains graphs of all models combined.

5.1.1 Development of a precipitation deficit under RCP4.5

The majority of the models project a slightly decreasing trendline, indicating an increase in summer precipitation deficit. This suggests that the chances of a higher precipitation deficit towards the future will grow, increasing the probability of exceedance. Following this rationale, one would assume that the thresholds would be passed more often towards the end of the century. However, this does not occur. Even though most models predict a declining trend, the varying range of precipitation deficit projections stands out. The thresholds only dominantly exceed in hadgem2-es (Figure 5.1.a). Gfdl-em2m projects a few exceedances, yet towards the end of the century, a precipitation surplus is more likely than a precipitation deficit (Figure 5.1.b). Ipsl-cm5a-lr projections do not even come close to the thresholds (Figure 5.1.d). Miroc-esm-chem seems stable, yet with several exceedances that appear to be attributed to climate variability (Figure 5.1.e). Only the noresm1-m model, similar to the hadgem2-es model, projects an apparent increase in precipitation deficit under RCP4.5, but merely at the end of the century a threshold is exceeded (Figure 5.1.c). What can be seen in Figure 5.1 is that the threshold exceedances seem outliers instead of exceedances due to climate change. The intermodel variability generates a high degree of uncertainty in this threshold exceedance analysis and will have implications for the turning point analysis.

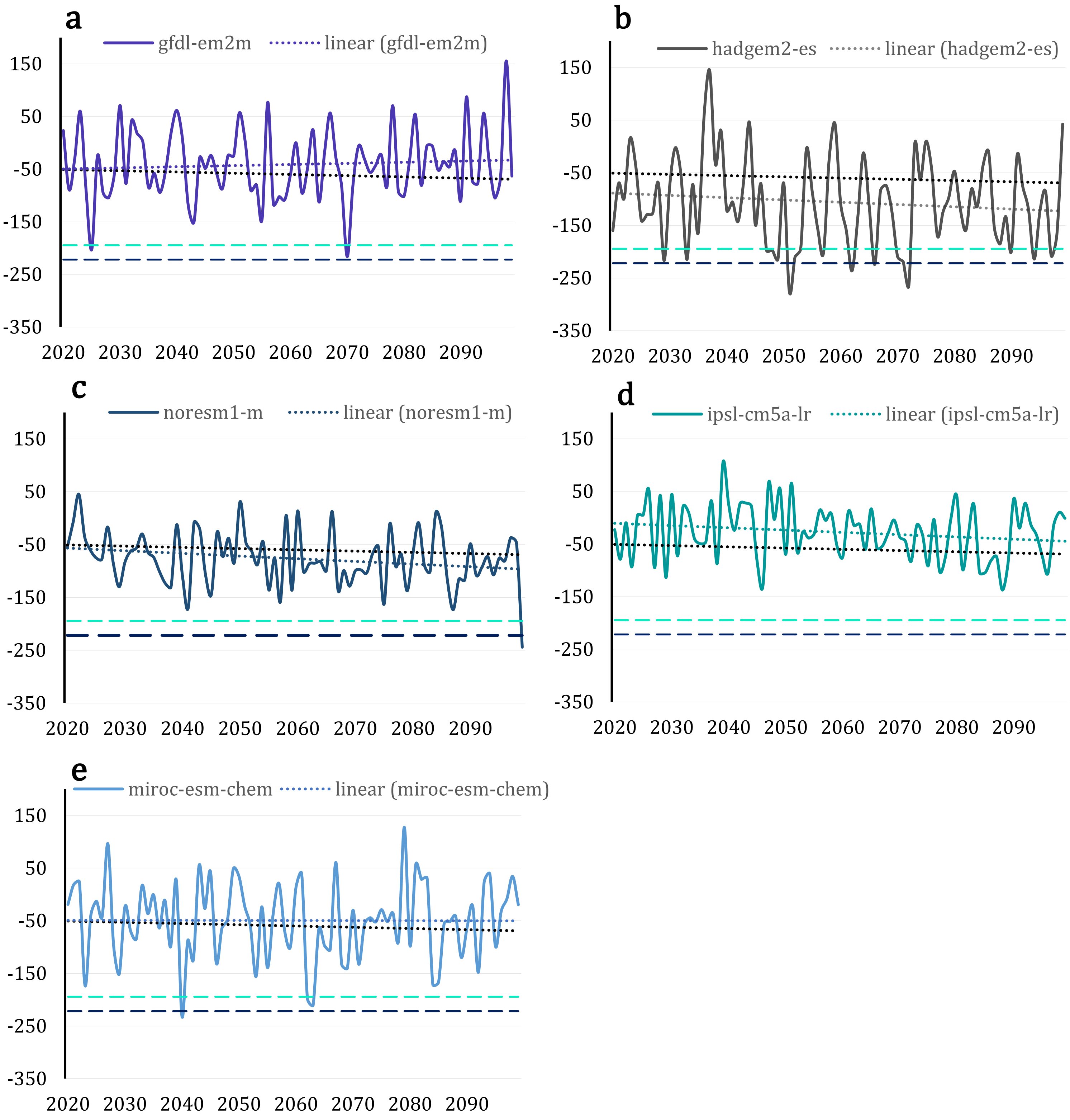

Figure 5.1. *Development of the summer precipitation deficit and the thresholds for 2003 and 2018 according to ISIMIP models gfdl-em2m (a), hadgem2-es (b), noresm1-m (c), ipsl-cm5a-lr (d) and miroc-esm-chem (e) under RCP4.5. The black dotted line indicates the average linear trendline. The lighter dotted lines denote the trendline of the specific model. The sea green and dark blue striped lines mark the 2003 and 2018 threshold.*

5.1.2 Development of a precipitation deficit under RCP8.5

Though most models under both scenarios project a steadily decreasing trendline, the models under RCP8.5 paint a substantially bleaker picture than RCP4.5. By extension, under this climatic scenario, the models show an increase in summer precipitation deficit between 50 mm and 110mm from now till the end of the century. This implies that the chances of a higher precipitation deficit will grow, increasing the probability of exceedance towards the future. In contrast to the projections for RCP4.5, this assumption holds up better for the model projections under RCP8.5. Under RCP8.5, the thresholds seem to steadily exceed by 2050 for the lower threshold and by 2080 for the higher threshold. Admittedly, this does not apply to every model. Here too, the intermodel variability is high. For instance, gfdl-em2m projects a few exceedances over the entire period (Figure 5.2.a). In contrast, both noresm1-m (Figure 5.2.c) and hadgem2-es (Figure 5.2.b) project to pass the thresholds more towards the end of the century. While this may not apply to threshold exceedances for ipsl-cm5a-lr (Figure 5.2.d) and miroc-esm-chem (Figure 5.2.e), the graphs show that the deficits are increasing too. Projected threshold exceedances under RCP8.5 seem more consistent in the future and suggest these may not be chance events. Despite this, the intermodel variability causes a considerable amount of uncertainty.

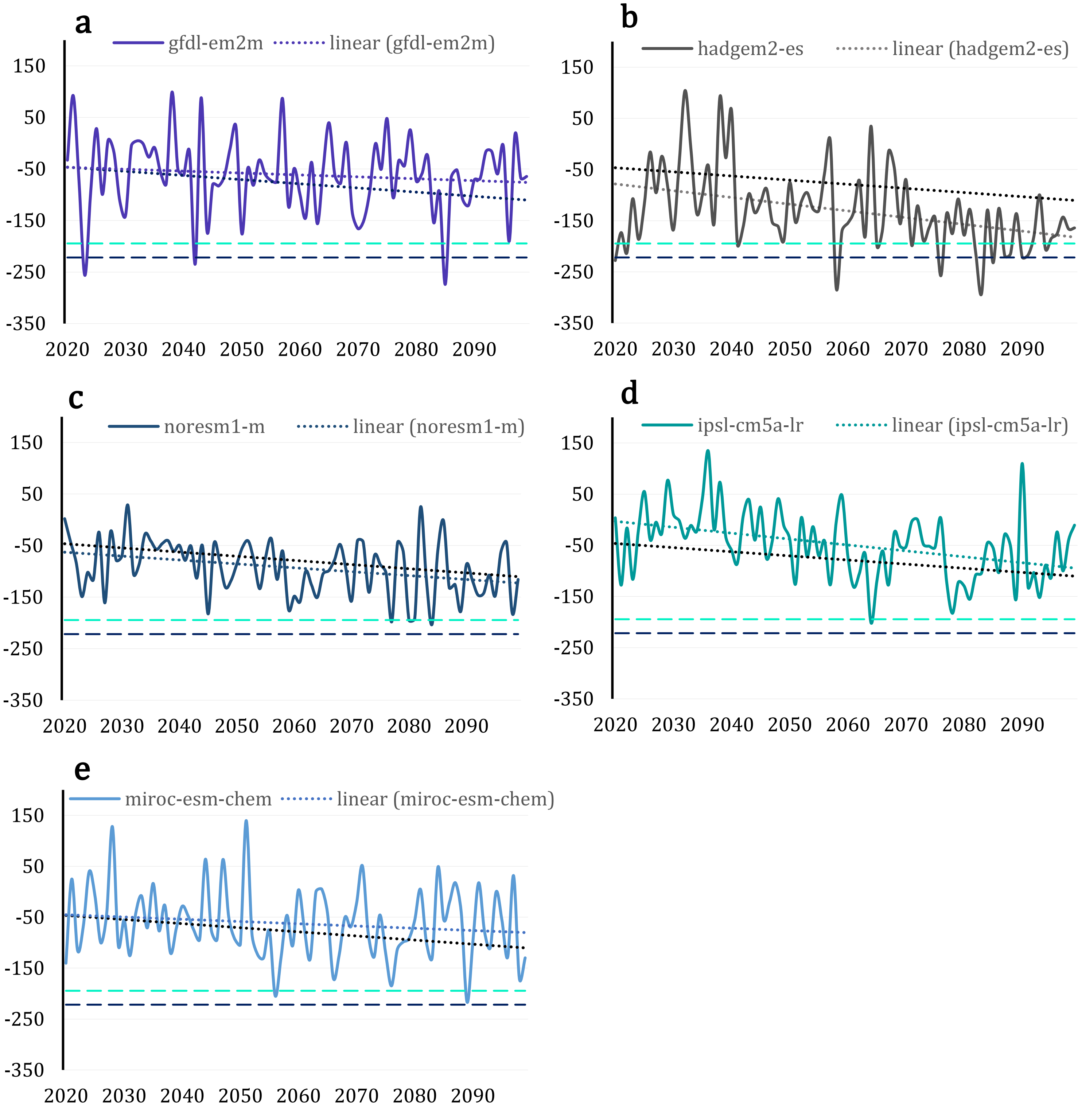

Figure 5.2. *Development of the summer precipitation deficit and the thresholds for 2003 and 2018 according to ISIMIP models gfdl-em2m (a), hadgem2-es (b), noresm1-m (c), ipsl-cm5a-lr (d) and miroc-esm-chem (e) under RCP8.5. The black dotted line indicates the average linear trendline. The lighter dotted lines denote the trendline of the specific model. The sea green and dark blue striped lines mark the 2003 and 2018 thresholds.*

5.2. Turning points

To determine when a turning point is reached, the analysis compared the precipitation deficit with the thresholds identified in the previous chapter. Because all precipitation deficit scenarios are chosen at least once, the assessment includes all frequencies (Table 5.1).

Table 5.1. *The scenarios and corresponding expected frequency.*

2003	Frequency	2018	Frequency
Every 2 years	1:2	Every 10 years	1:10
Every 3 years	1:3	Every 15 years	1:15
Every 8 years	1:8	Every 25 years	1:25

What has essentially been presented to the farmers are return periods or recurrence intervals. In essence, a 2-year deficit has a chance of occurring at least once every two years. Note that an estimated return period of 1:2 does not suggest that the deficit will reoccur precisely every two years.

5.2.1. Turning points for the 2003 scenarios

Tables 5.2 and 5.3 present the expected frequencies for exceedances of the 2003 summer deficit under RCP4.5 and RCP8.5. An example taken from the table below; both hadgem2-es and gfdl-em2m predict one exceedance year for the 194.5mm threshold for the decade 2020-2029. One exceedance in ten years (1:10) is too little to top the expected frequency of the return periods for 2003 (1:2, 1:3, 1:8).

Table 5.2. *The observed frequency the five climate models predict for when the precipitation deficit exceeds a deficit of 194.5 under RCP4.5.*

	gfdl-em2m	hadgem2-es	ipsl-cm5a-lr	noresm1-m	miroc-esm-chem
2020-2029	1:10	1:10	-	-	-
2030-2039	-	1:10	-	-	-
2040-2049	-	1:3	-	-	1:10
2050-2059	-	1:3	-	-	-
2060-2069	-	1:5	-	-	1:5
2070-2079	1:10	1:3	-	-	-
2080-2089	-	1:2	-	-	-
2090-2099	-	1:3	-	1:10	-

Table 5.3. *The observed frequency the five climate models predict for when the precipitation deficit exceeds a deficit of 194.5 under RCP8.5.*

	gfdl-em2m	hadgem2-es	ipsl-cm5a-lr	noresm1-m	miroc-esm-chem
2020-2029	1:10	1:5	-	-	-
2030-2039	-	-	-	-	-
2040-2049	1:10	1:10	-	-	-
2050-2059	-	1:10	-	-	1:10
2060-2069	-	1:10	1:10	-	-
2070-2079	-	1:5	-	1:10	-
2080-2089	1:10	1:2	-	1:5	1:10
2090-2099	-	1:3	-		-

Furthermore, the table shows that under RCP4.5, the lowest threshold of every eight years is exceeded mostly around mid-century but might not reach the other two return periods of every two years and every three years. In contrast, under RCP8.5, it is expected that all thresholds will be reached around the end of the century. Even more, this is predicted by almost all climate models under RCP8.5, contrary to RCP4.5, for which merely two out of five expect deficits of this magnitude.

5.2.2. 2018

Tables 5.4 and 5.5 present the expected frequencies the models predict for exceedances of the 2018 summer deficit for RCP4.5 and RCP 8.5.

Table 5.4. *The observed frequency the five climate models predict for when the precipitation deficit exceeds a deficit of 221.8 under RCP4.5.*

	gfdl-em2m	hadgem2-es	ipsl-cm5a-lr	noresm1-m	miroc-esm-chem
2020-2029	-	-	-	-	-
2030-2039	-	-	-	-	-
2040-2049	-	-	-	-	1:10
2050-2059	-	1:10	-	-	-
2060-2069	-	1:5	-	-	-
2070-2079	-	1:10	-	-	-
2080-2089	-	-	-	-	-
2090-2099	-	-	-	1:10	-

Table 5.5. *The observed frequency the five climate models predict for when the precipitation deficit exceeds a deficit of 221.8 under RCP8.5.*

	gfdl-em2m	hadgem2-es	ipsl-cm5a-lr	noresm1-m	miroc-esm-chem
2020-2029	1:10	1:10	-	-	-
2030-2039	-	-	-	-	-
2040-2049	1:10	-	-	-	-
2050-2059	-	1:10	-	-	-
2060-2069	-	-	-	-	-
2070-2079	-	1:10	-	-	-
2080-2089	1:10	1:5	-	-	-
2090-2099	-	-	-	-	-

Given that the precipitation deficit for the summer of 2018 is much higher compared to the summer of 2003, it is comprehensible that not all models predict this summer to reoccur as frequently. As shown in the table, for both RCPs, there are five decades in which climate models predict a deficit similar or worse to the deficit in 2018. For RCP4.5, most thresholds exceedances are around midcentury, yet this only occurs in one model. Under RCP8.5, the thresholds are exceeded consistently over the century, but this only occurs in two models. From both tables follows that the analysis cannot claim anything with certainty about the timing of the 2018 threshold due to the model variability.

5.2.3. Conclusion

This chapter aimed to estimate when the thresholds may be exceeded, as to provide an answer to the sub-question: which landscape values of farmers can be translated into thresholds for social turning points?" Accordingly, the analysis gathered additional insight on how the climate might develop towards the end of the century. However, the unpredictable behaviour of the meteorological variables generates a high level of uncertainty when pinpointing adaptation turning points. It is therefore difficult to identify a turning point for the uncertainties in and the variability between the climate models.

Even though the analysis could not pinpoint the turning points, it does not imply that the research cannot answer the final sub-question. From Chapter 4 follows that the sections on perceived impacts and landscape values willing to take action for generated the same values; namely economic, identity, life-sustaining, and future. Because the values are the same for each of these questions, the research can say with relative certainty that the values representing a significant departure from current farming proceedings are also impacted when the turning points occur. In other words, these are the values farmers perceive to be negatively impacted by an increase in droughts; when the first turning points may appear in the future, farmers are likely to act on these values. Admittedly, the intermodel variability is too large to draw conclusions on when turning points will occur. Therefore, the reader should view the results as a proof-of-principle rather than a prediction of when social turning points will occur.

6. DISCUSSION

After demonstrating a values-based approach to social turning points, it is time to assess the lessons learned along the way. This chapter first situates the results within the existing literature on the topic, then reflects on the decisions taken and how these impact the results in order to give recommendations in the end.

6.1. Placing the findings within the existing literature on the topic

A non-participatory approach makes it difficult to develop strategies that are widely supported. Hence, there is a need for social and bottom-up established thresholds to regulate risk to what is important for farmers. Accordingly, this research aimed to expand on the limited scientific literature on social and bottom-up established thresholds by exploring whether it is possible to use landscape values as thresholds for social turning points. It became clear early into the research that directly translating landscape values, or any type of value, into a quantifiable threshold for turning points is not feasible. Still, a combination of the methods by Barnett, Fincher, et al. (2014) and Ramm, Watson, and White (2018) derived an indirect approach to translating landscape values into thresholds for turning points. The first paragraphs describe how the insights gathered in this research contribute to the existing literature on using a values-based approach to adaptation turning points. The section thereafter compares the results to similar research.

6.1.1 Supplementary insights in the methodology

First, the research upholds the findings in previous literature on how landscape values may promote sustainable behaviour in people (García-Martín et al., 2018; Ives & Kendal, 2014; Van Riper & Kyle, 2014). It turned out that under the presented drought scenarios, farmers would consider additional measures to protect their most important landscape values, should these be compromised by increasing drought. With this link, it was imperative that the method distinguished between the different values (Masterson et al., 2017). Even if people are attached to a specific location, how people act differs based on what value is threatened by environmental change. This is a significant finding because the type of importance people assign to a specific physical location can lead to transformational change (Abson et al., 2017; Masterson et al., 2017). Transformational change is crucial for the system change required for long-term development in the face of climate change (Werners, Wise, Butler, Totin, & Vincent, 2021).

Second, past experiences for thresholds seem a very effective tool to establish thresholds because past experiences are comprehensible. Especially for the uncertainty and complexity surrounding climate change-induced droughts, it is not easy to reason whether a never encountered occurrence is acceptable (Barnett, Graham, et al., 2014). Hence, the first-hand experience of environmental change is a more effective trigger for adaptation, particularly when the values deemed important are negatively affected. The logic of these events follows from that they are founded upon past changes in the environment, whereby farmers can comprehend fairly well whether or not their landscape values are perceived to be at risk and whether they are willing to take action on their part. In this way, the method reduces the ambiguity in identifying thresholds. Several other studies similarly endorse the use of past experiences for creating an incentive for people to adapt to climate change and promote sustainable behaviour

(Barnett, Graham, et al., 2014; Kollmuss & Agyeman, 2002; Macgregor & van Dijk, 2014; McSweeney & Coomes, 2011; Rosenzweig & Solecki, 2014; Spence, Poortinga, Butler, & Pidgeon, 2011; Wyborn, Yung, Murphy, & Williams, 2015).

Third, as mentioned in Chapter 2, most adaptation pathways are determined by top-down approaches because incorporating the varying viewpoints of stakeholders makes it more difficult to find a consensus on bottom-up thresholds (Barnett, Graham, et al., 2014; Bosomworth & Gaillard, 2019; Werners et al., 2015). Instead, as the results show, there are unmistakably corresponding values important to nearly all farmers. Also other studies, no less with a broader focus group, have identified many matching values essential for almost everyone in the region (Graham et al., 2013; Ramm et al., 2017). Likewise, by using past experiences there were similarities between farmers. Barnett, Graham, et al. (2014) endorses the feasibility by which these experiences can determine consensus on climatic thresholds. Surely, there will always be people who disagree. Nonetheless, it is reasonably manageable to find consensus for thresholds built on a participatory approach.

6.1.2 Comparing the results

The research used a combination of landscape values and thresholds based on previous drought experiences to determine the social turning points. As this study offers the first effort for a values-based approach to social turning points for drought, existing research does not easily compare to the overall results. Nonetheless, it is possible to contrast the separate result sections – landscape values and climatic thresholds – to different studies.

The most frequently cited landscape values by farmers in this study are the life-sustaining value, the economic value, the identity value, and the future value. This is in congruence with the values derived from the interviews. These results are similar to those reported by studies that have explored landscape values for farmers in other European countries. For instance, while Raymond, Bieling, et al. (2016) conducted their study in South West England, they found similar values to the life-sustaining and identity value in this study. However, in the study by Raymond, Bieling, et al. (2016), farmers mentioned the social relations and biodiversity value more often. These values rank somewhere in the middle in this study. Although it may be an intercultural difference, it is also possible that the difference in the formulation of the question yields other values. Nevertheless, conceding that Raymond, Bieling, et al. (2016) did not use a set list of landscape values but asked farmers what they deemed important about their company, their community, and their role as a steward, the similarity between the results supports the overall significance of the findings in this study. The same holds true for the research by Busck (2002), who explored landscape values by interviewing farmers in Jutland, Denmark. The most important landscape values identified are congruent with the life-sustaining value, the economic value, and the relationship between agriculture and nature, endorsing this research's results.

Other research has tried to determine non-participative turning points for drought in different regions (Cradock-Henry et al., 2020; Maru et al., 2014; Mortazavi-Naeini et al., 2015). These studies have mostly used the variables temperature, precipitation and evapotranspiration as indicators for drought. Similarly, they have faced comparable challenges in the climate model variability and the uncertainty to project these thresholds.

However, contrary to this research, this did not deter them from pinpointing turning points for adaptation pathways. The following limitation section further expands on the decision not to determine the turning points in this study.

6.2. Limitations

Having discussed the findings, the following section of this paper addresses the results' limitations. In particular, the section elaborates on the limitations of using a survey for assessing landscape values, applying a values-based approach to adaptation, using past experiences for thresholds, employing drought for climatic thresholds and the generalizability of the methods and results.

6.2.1. Surveys to assess landscape values

When designing the survey, special emphasis was put on several considerations to address the drawbacks and biases of surveys as much as possible. This includes the response bias, the validity rate, socially desirable responding, and the low response rate, as these are commonly known to hinder surveys (Bhattacherjee, 2012). Surveys were very effective as a tool in this research. The set list of values derived almost the same top-rated values as in the studies with an interview approach such as Busck (2002) and Raymond, Bieling, et al. (2016), and in this research's interviews. This suggests that a survey can be just as effective in unravelling values as interviews. However, there are still several limitations to assessing landscape values by survey.

First, there were difficulties reaching several farmers online. Some computer systems do not support Microsoft's survey program. The program itself has had some updates during the survey distribution. Therefore an identical survey sent thereafter should have resolved the glitches. However, it is unknown how many farmers refrained from filling in the second questionnaire because of the first glitch.

Second, the whole idea behind a values-based approach to adaptation is that adaptation measures find a larger support base when adaptation is framed to regulate risk for a local vision. However, a farmer can say something is of value, but that does not imply that the farmer will act upon that value when threatened. There is a difference between articulated values and enacted values (Fitzpatrick et al., 2016; Graham et al., 2014). By differentiating between what values farmers find important (articulated) and which values they would act upon (enacted), this limitation has been partly overcome. From Chapter 4, it can be gathered that not all values rated as important are values farmers would take action for. Therefore, the values farmers say they will act upon are the basis for the turning points. Admittedly, even though turning points harbour these values, it does not imply that farmers will truly enact upon these values when push comes to shove. On the other hand, the thresholds do not only base themselves on landscape values. The thresholds also conform to the direct experiences of farmers. Direct experiences are known to bring forth sustainable behaviour (Kollmuss & Agyeman, 2002; Masterson et al., 2017), which circumvents this limitation. Nevertheless, it is arguable whether presenting drought scenarios will generate the same support base as enacted landscape values. Further research should investigate how farmers would act upon their most important values.

Third, the results show that while some farmers did find certain values important (Chapter 4.2), they were not inclined to take action (Chapter 4.5). This applies, amongst others, to the social relations value. It is not clear from the survey whether they do not want to take action for the social relations value because it is not valued enough to take action, or, if the farmer does not believe increased droughts can impact the social relations value and therefore does not consider it necessary to take action. Additionally, it may well be the case that they would only want to undertake additional measures if a combination of values is impacted. Moreover, farmers may not understand how they can prevent the deterioration of some values. Consequently, farmers may be inclined to act upon the change in values, but they did not report this for the preceding reasons. This alludes to the limitation that perhaps relevant landscape values may not have emerged in the turning point analysis.

6.2.2. Limitations to a values-based approach to adaptation

Aside from the limitations to using a survey to determine values, there are drawbacks to using values for adaptation turning points. The following section discusses these limitations.

First, values are not static but can change over time. What seems to be important now may not be important to someone in 30 years. For instance, changes in relationships can be of influence, with neighbours, local village, profession, and someone's connection with the environment and culture of the region (Siebert, Toogood, & Knierim, 2006; Tschakert et al., 2017). Given that adaptation measures often have long-term goals, this can be problematic because values can change. To make matters more complicated, climate change can change our perception of what we find important. For instance, if something becomes more valuable due to scarcity. At that time, values may rate very differently. Even if values and trade-offs remain the same for individuals, adaptation management means making decisions for a 50-to-100-year period. Values, including their trade-offs, will change with each passing generation (Tschakert et al., 2017). A values-based approach to adaptation of what to save in the future is complex because what may be important now may not be important in the future. However, it is necessary to note that turning points are a tool to communicate how today's measures may not meet stakeholders' requirements in the future. While values may change in the future, this does not detract from the tool's efficacy as a communication instrument. Turning points are not fixed things; it is essential to re-evaluate and perhaps adjust every so often.

Second, it is necessary to keep in mind that farmers are not the only water-users in the region. Ultimately, the goal is to develop widely supported adaptation. This demands a wider knowledge of values for different groups within the community (Graham et al., 2014). Whose values are further considered in the decision-making process is dependent on complicated and perhaps even contested power relations (Masterson et al., 2017).

6.2.3. Past experiences for thresholds

The same limitations mentioned in Chapter 6.2.2 apply to farmers' perceptions of risk and what they deem an unacceptable situation. In particular, an unacceptable situation is not only highly context-specific and different for every individual, but people's outlook on an unacceptable situation, including the perceived risk to their values, can change over time, and they may gain new insights. There are additional drawbacks that specifically apply to using past experiences as a basis for climatic thresholds. The following paragraphs discuss these limitations.

First, it is necessary to note that the survey presented merely two scenarios to the farmers. Admittedly, the survey did incorporate an option for farmers to indicate their own unacceptable scenario. However, farmers may not have reported other unacceptable scenarios. Still, all farmers indicated during the interviews that the droughts in the last few summers are highly problematic. This suggests that at least the 2018 drought represents an unacceptable threshold for farmers. However, it is necessary to point out that merely three farmers were interviewed; this sample is not representative for all farmers in the region.

Second, the research assumed that the unacceptable situation in the summers of 2003 and 2018 resulted from a high precipitation deficit. Hence, the reason for translating a precipitation deficit into a climatic threshold. However, the survey merely asked farmers to choose which scenario constitutes unacceptable but not why. Farmers could have chosen the scenario because of the high precipitation deficit. It could also be the case that the ban on irrigation water from surface waters[3] came at a moment in time that was essential for crop development. Although the emphasis in the survey was on the meteorological properties of the summers, it is not possible to pinpoint whether the meteorological variables were actually the driver behind the decision. As will be further detailed in section 6.2.4, agricultural drought is often the result of much more than merely a precipitation deficit (Sepulcre-Canto et al., 2012). Future research should ask farmers what made the summer scenarios unacceptable.

Third, when drawing upon farmers' past experiences, the thresholds essentially focus on problematic conditions that are known to be an issue in accordance with their prior experience of drought. While their viewpoint is crucial for determining social turning points, the thresholds do not consider unfamiliar problems. For instance, climate change can exacerbate certain drought impacts that are not a problem now but may become problematic in the future. This means that the thresholds can also shift.

6.2.4. Meteorological drought as a climatic threshold

Aside from the limitations on using values and past experiences for determining turning points, there are specific shortcomings to using drought, meteorological drought in particular, for determining when the turning points occur. The following section discusses these limitations.

Drought is a complicated phenomenon. Many definitions of drought circulate between different fields of study, depending on a vast array of hydroclimatic drivers and impacts that such an event may bring about on various sectors (e.g. agriculture, industries) and ecosystems (Mukherjee et al., 2018). As mentioned in the theoretical framework, this research used simplistic climatic conditions to project drought. Drought is dependent on so much more than this one meteorological variable (Mukherjee et al., 2018; Sepulcre-

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[3] The ban on surface irrigation began on the 18th of June, 2018 (Waterschap Limburg, 2018).

Canto et al., 2012; Wang, Ertsen, Svoboda, & Hafeez, 2016). It would have been more logical for farmers to study agricultural drought instead of meteorological drought. While a precipitation deficit can be an effective indicator of agricultural drought (Sepulcre-Canto et al., 2012), the use of a precipitation deficit as a translation for drought is a shortcoming in this analysis. There are many agricultural drought indicators other than a precipitation deficit that can project a problematic situation for farmers. However, this study aimed to provide proof-of-principle whether it is possible to use a values-based approach to adaptation for drought. Because agricultural drought is too complex it falls outside the scope of this study. However, it would be helpful to investigate this in future research.

Moreover, the decision was made in this thesis to calculate the precipitation deficit over the summer months June, July and August. However, drought can occur outside these months. The researchers of the KNMI start measuring drought from the first of April until the first of October, called the drought season (KNMI, 2019). From this moment, trees come into leaf and evaporation increases. According to the definition adopted in this thesis, a drought can already occur in April, May, and September. Therefore, some droughts may not have appeared in the analysis.

Besides, as became clear from the figures in the previous result section, there are significant uncertainties regarding the projections. Even though most linear trend lines showed either a decrease or an increase, particularly under RCP8.5, the climate models are far apart regarding their predictions. Ipsl-cm5a-lr, noresm1-m, and miroc-esm-chem paint a more positive picture of the future than hadgem2-es and gfdl-em2m. Both precipitation and shortwave radiation are highly unpredictable, visualised by the erratic nature of the graphs. The frequency of drought occurrences not only varies between climate models but also between scenarios. Predictions always come with uncertainties because all climate models make assumptions on climatic factors such as feedback loops, climate sensitivity, and the atmosphere's future composition (Watson, 2008). However, using extreme events instead of climatic trends for thresholds makes pinpointing turning points even more uncertain. Extreme events occur irregularly due to complex dynamics (Ghil et al., 2011). Combining the climate models to look at trends may reduce the uncertainty and variability. Yet, once the mean of the models was derived, it never reached the threshold because incorporating the mean removes the variability. Therefore, only analysing trends is not suitable because drought is an extreme event. For this reason, climatic trends, such as sea-level rise and temperature change, are more straightforward, albeit still precarious, to predict (Kumar, Merwade, Kinter, & Niyogi, 2013).

Moreover, meteorological drought is still not well incorporated into climate models (Ault, Cole, Overpeck, Pederson, & Meko, 2014; Kumar, Merwade, Kinter, & Niyogi, 2013; Moon, Gudmundsson, & Seneviratne, 2018; Mukherjee et al., 2018). While research has shown that long-term temperature projections are pretty reliable, radiative forcing and precipitation are highly unreliable (Kumar et al., 2013; Mukherjee et al., 2018). The reason for this is because global models cannot fully account for cloud cover and wind speed; it is unknown how these variables will develop. Besides, these variables are highly region-specific. The 0.5° by 0.5° pixel scale of the global model cannot account for heterogeneity on a sub-grid scale, the same way regional models adjusted by historical observations may display more uniform projections (Jang & Kavvas, 2015). To put the scale into perspective, a 0.5° by 0.5° pixel scale is the equivalent of 55km by 55km. The scale used in this research accounts for a surface 1.5 times the size of Limburg and over 200 times the size of the Mariapeel. This raises the question whether the results can say something about the frequency of drought in the future for a region as small as the Mariapeel. On the other hand, the global models are continuously improving. The Coupled Model Intercomparison Project 5 (CMIP5) already yields more reliable drought projections than CMIP3 (Kumar et al., 2013). Hence, closely monitoring climate model developments may be of interest for future drought projections.

6.2.5. Generalizations

6.2.5.1 Generalizing the results

Can the results on thresholds be generalised to farmers in other regions? Supposing that this sample provides a good representation for the area around the Mariapeel, does this also apply to the rest of the farmers in Northern Limburg or even the rest of the province? The research's local scale has implications for the scale at which transformational change for adaptation can occur (Masterson et al., 2017). From a scientific perspective, the study would need to be replicated in another part of Limburg to verify the results.

As for generalising the landscape values results, one could argue, given the similarities between this study and the research by Raymond, Bieling, et al. (2016) and Busck (2002), that most of the farmers' landscape values in the Mariapeel are not uncommon. Yet, there are arguments against the extrapolation of values. Values are inherently unsuitable for widespread generalisation because individual subjective judgements do not reflect collective judgements (Tschakert et al., 2017). On the other hand, some studies have shown the external validity of values replicating the research in different regions (Greg Brown & Brabyn, 2012; De Vries, Lankhorst, & Buijs, 2007).

The same small sample of farmers who identified the landscape values also determined the thresholds. Can the identified thresholds be extrapolated to other farmers in other regions? In other words, will farmers in the different areas also identify the summer of 2018 once every *X* years as an unacceptable scenario? This question adds a layer of complication to the landscape values reasoning for extrapolation because of the differences in local hydrology and geomorphology. The further away from the case study, the more difficult it becomes to extrapolate the results. This goes further than the subjective differences between farmers. Droughts are experienced differently based on differences in a region's hydrology and geomorphology (Sepulcre-Canto et al., 2012). For instance, farmers in the eastern part of Gelderland may not have experienced the drought in the summer of 2018 as problematic because the precipitation deficit was not as significant due to local rainfall events (Sluijter et al., 2018). The same applies to areas where the ground was better able to keep water or where the water authority did not prohibit the use of surface water for irrigation. For these reasons, it is not possible to extrapolate the results regarding the thresholds to other regions.

6.2.5.2 Generalizing the methods

The question remains whether you can use the methods in this research for other stakeholders and climatic risks. The short answer is yes, with several changes to the methodology.

The method in Chapter 3.3.1 describes how the survey adjusts to farmers in two ways. First, the landscape values definitions tailor to farmers' property. This question is not applicable for most people because their property and livelihood will not be directly affected by drought. However, other locations in the region may be negatively affected by drought. For instance, the nature reserve the Mariapeel can be impacted. So for other locals, the survey might ask whether they perceive their values to be negatively impacted by drought and for which values they would want to take measures. Second, the scenarios for the climatic thresholds are adjusted to farmers' experience because these two years were problematic for farmers. However, other people may not have experienced these years as problematic because they did not see direct effects. Moreover, a precipitation deficit is not a term most people hear regularly. Therefore, the unacceptable scenarios in the survey should tailor to comprehensible impacts for the target group. For instance, in 2020, the nature reserve adjacent to the Mariapeel caught fire because it was too dry (Gemeente Deurne, 2020). The fire may have bothered locals. Alternatively, other research can indicate how much the natural area has disappeared due to the drought of 2018. In short, it is possible to replicate the methods. An important condition is that the survey focuses on a specific area, for instance, a nature reserve, the beach or someone's property.

It is also possible to replicate the methods for other climate risks. Barnett, Graham, et al. (2014) and Ramm et al. (2017) conducted a values-based approach to flooding. It is also possible to do this for salinization, wildfires or even eutrophication. However, the indicator(s) used to identify the climatic thresholds and how to make the unacceptable scenarios understandable for others is something to consider carefully.

6.3. Recommendations

The following section highlights several recommendations and possible future research and policy approaches.

6.3.1 Building upon identified improvements

Future research should focus on several improvements identified in the discussion based on the limitations discussed. First, follow-up research should focus on which drought indicator farmers deem unacceptable. Based on the interviews, the research presumes that irrigation bans on (sub)surface waters play a part in the threshold decision. Future research should look into viable drought indicators that can be used to determine adaptation turning points. Second, this research recommends using a regional model instead of a global model because the regional model may better account for heterogeneity. It would be interesting to see whether the regional model produces different outcomes. Last, conducting interviews instead of surveys might resolve several drawbacks such as that the interviewee has the chance to ask clarification questions if they are unsure about the question.

6.3.2 Building upon new insights

Future research can build upon the successes uncovered in this research. First, subsequent analyses should consider replicating this study for other water users and other climatic risks in the region. The reproduction ought to incorporate landscape values and past experiences. This creates a more holistic view of the values that play a role in the region, which subsequently frames adaptation strategies to regulate risk to a local vision, and gives researchers and policymakers a tool to promote sustainable behaviour. It would also be interesting to apply the approach to farmers in other regions to determine if the top-rated values remain the same. The research can also be carried out on a national scale, for example, by incorporating the questions into a national survey.

6.3.3 Building upon values for adaptation measures

By unravelling what farmers consider an unacceptable situation, when this situation is likely to occur, and which values drive this decision, this study sets out the beginning of a more participatory approach to adaptation. After all, if the thresholds for turning points can be framed to regulate risk for a local vision, adaptation measures can be framed similarly. Instead of basing strategies solely on the expected environmental impacts of drought, measures can be rated based on the most important values – economic value, life-sustaining value, identity value, future value – as identified in Chapter 4.2. What farmers deem important ultimately affects farmers willingness to take action, influencing the threshold values, and is therefore important to keep in mind.

The analysis below (Table 6.1) offers a starting point for examining how adaptation measures can affect important landscape values of farmers' property and tolerable trade-offs for the sake of drought reduction. The assessment used the adaptation measures proposed in the Water Management Program for 2022-2027 to determine the estimated benefit or harm to the most important landscape values. The analysis also considers the relative costs to farmers and the time it may roughly take till the measure pays off. Annex F contains the rationale for this assessment.

Table 6.1. *A way to rate LIWA measures against the most frequently mentioned important landscape values, as inspired by the methods from Ramm et al. (2018).*

	Estimated benefit or harm to top-rated landscape values [1]					
LIWA measures	Economic	Future	Identity	Life-sustaining	Relative costs to farmers [2]	Time to benefits
Sub-irrigation[3]	+	++	±	++	€€	Short
Soil infiltration	±	++	±	++	€	Long
Reservoirs at summer level	±	++	+	+		Short

[1] '±' either small benefit or harm; '+' small benefit; '++' large benefit
[2] Initial investment costs
[3] Based on the knowledge there is now, specifically from LIWA and a pilot project in the Peel.

Environmental policies and measures can merit by tailoring them to the values of individual farmers. It is important to acknowledge that this reasoning can only be maintained in a situation where there are plentiful resources to produce policy instruments that can adapt measures to each individual farmer. This is not realistic because there are not enough resources available to do this. What it does, is it opens up a new dialogue on enhancing adaptation pathways to conserve important landscape values of farmers.

The rating of these values base itself on the interpretations of the values. However, neither the survey nor the interview asked for them. For this reason, the interpretations in this approach are an estimation of what is said during the interviews. Understanding the different interpretations of the values is unnecessary when establishing turning points, but this becomes crucial once measures are rated based on specific interpretations of values, as is done in Table 6.1. Values are highly context-dependent; this is more difficult to assess through surveys because it can only show the external face of a value. This difficulty became evident when one of the farmers mentioned in the survey that while the farmer found great importance in the biodiversity value, the abundance of certain species became a serious problem for the crops. Admittedly, while no meaning is precisely the same, the interpretations of these values frequently match for distinct kinds of people in the same region (Masterson et al., 2017). Farmers in the area of the Mariapeel may have the same interpretation of values. However, the assessment in Table 6.1 still needs validation. Follow-up research should discuss with farmers how they interpret the values.

Besides, the trade-off assessment raises the question of which trade-offs are acceptable for farmers. Knowing which values are more important to protect is essential when assessing the adaptation measures. Although one can reasonably estimate this from the number of times a particular value rates as 'important', the highly subjective nature of the analysis needs farmers' validation. For example, increasing soil infiltration may harm the economic value because the investment costs can impact short-term revenues. However, it could also strengthen the life-sustaining value by enhancing soil organic matter in the long term, subsequently improving land quality. The question remains which value farmers deem more important. Additional research is needed to address the trade-offs between values, for instance, by ranking the values. The analysis presented in Table 6.1 does, however, give a clear starting point for policy-makers to consider how measures affect farmers landscape values, especially when designing possible strategies and pathways in the initial phase of the process. Nonetheless, this does not make it any less imperative from engaging with farmers to agree on final decisions on adaptation measures. This is an effective tool in the beginning stages of the adaptation process and cannot be used as a means for policy-makers to validate final decisions on adaptation measures.

7. CONCLUSION

Climate change adaptation does not occur in isolation but happens in concert with other objectives such as climate mitigation, renewable energy, water quality and the economy. Measures have to take these development goals into account too. Hence, adaptation cannot detach from this overarching and holistic comprehension of development in the Netherlands. So why make adaptation even more complicated by including local values? Because at the moment, adaptation pathways and turning points are dominated by top-down and technically determined approaches. The adaptation response will neither be accurate nor effective if we keep sustaining this climate adaptation narrative of researchers, technicians and politicians, and do not move towards including local knowledge and values. For this to happen, the paper began by asking the following question: *Can landscape values be translated into thresholds for adaptation turning points of farmers in the Mariapeel, Limburg?* To come full circle, the final step of this thesis is to provide an answer to this question.

The research demonstrates a proof-of-principle. It is feasible to develop social turning points based on landscape values, albeit indirectly. It is possible to determine which values farmers believe are negatively affected by increased drought and at what point they are likely to act on this. Combining this data generates the turning points. In compliance with the analyses on landscape values and climatic data, the research concludes that the economic value, the life-sustaining value, the future value and the identity value may be jeopardized by increased drought in the future, to such an extent that the farmers will act upon that change. However, the turning point analysis should be approached with caution due to the uncertainty in and variability between climate models. Future research must closely monitor threshold exceedances and drought developments and continuously evaluate drought indicators. Timely investments should be made before the first thresholds are passed.

This approach facilitates the development of adaptation strategies that are widely supported. The approach provides a simple entry point for researchers, local governments and farmers to implement measures at a speed in line with farmers' experiences and values. Contrary to what many may believe, it is reasonably manageable to design thresholds based on a participatory approach. However, as became clear, drought is a difficult concept to monitor. Hence, using drought as a concept meant that the last step in this research did not yield such useful results. Because the concept is complex, it is necessary to look carefully at which drought indicators to use. This does not detract from the efficacy of the methods, particularly for more straightforward concepts such as flooding.

The designed thresholds integrate local knowledge and experience, founded upon past changes in the environment, consequently overthrowing disputes from those who believe that climate change is neither real nor problematic. The research also recommends rating adaptation measures or pathways to prevent risk to local values. Environmental policies and measures can merit by tailoring them to the values of individual farmers at farmers' pace. It is necessary to recognize that this argument can only hold up in a world where there are enough resources and opportunities to create policy instruments that can tailor measures to each individual farmer. This is not even considering other water users in the region. Whose values are subsequently considered relies on complex and possibly contested power relations. This does not mean that a values-based approach to adaptation is fruitless. Eventually, it is important to support farmers, communities, policy-makers and researchers alike to determine how adaptation measures may minimise risk, what values are important to preserve, when to do this, and acknowledge that it is not possible to protect all values from environmental change. Additionally, it is important to re-evaluate and adjust the turning point analysis every so often, to assess its feasibility and applicability in light of environmental and social change.

All told, it is imperative to stress that the provided framework is an effective tool for researchers and policy-makers in the *beginning stages* of the adaptation process; it cannot be employed to validate final decisions or investments on measures or their implementation speed over the heads of local people. Representativity, debatability, and inclusivity throughout the adaptation process are the pillars we need to focus on for widely supported and effective adaptation.

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ANNEX A

QUESTIONNAIRE SURVEY

Both structured and unstructured questions are posed in the survey. The unstructured questions gave the respondents the opportunity to express their opinion, or present them with an opportunity to shed light on their previous answer. As for the structured questions, the survey included questions that could be either answered with multiple responses or with one response. The survey response scale included ordinal, nominal, and ratio scale items. The description of the type of questions, the scales and the sequencing per survey question is displayed in Table A.1.

Table A.1. *Description of all survey questions.*

Survey question	Structured or unstructured	One answer or multiple answer possible	Response scale	Point scale	The option of "I don't know"	Skip sequencing
1	Structured	One	Nominal	-	-	-
2	Structured	One	Ratio	-	-	-
3	Structured	Multiple	Nominal	-	-	-
4	Structured	One	Nominal	-	-	-
5	Structured	One	Ordinal	5-point	Yes	-
6	Unstructured	One	Nominal	-	-	-
7	Structured	One	Nominal	-	-	Yes
8	Structured	One	Ordinal	5-point	Yes	-
9	Unstructured	One	Nominal	-	-	-
10	Structured	One	Nominal	-	-	-
11	Structured	One	Nominal	-	-	-
12	Structured	One	Ordinal	4-point	Yes	-
13	Unstructured	One	Nominal	-	-	-
14	Structured	Multiple	Nominal	-	-	-

15	Structured	One	Nominal	-	-	Yes
16	Structured	One	Nominal	4-point	No	-
17	Unstructured	One	Nominal	-	-	-
18	Structured	One	Nominal	-	-	-
19	Unstructured	One	Nominal	-	-	-

Beste deelnemer,

Dank u voor uw deelname aan deze enquête.

Als student land en waterbeheer aan de Universiteit van Wageningen doe ik onderzoek naar de waarden die boeren hechten aan zowel hun boerderij in de omgeving van de Mariapeel als het natuurgebied de Mariapeel. De waarden die ik onderzoek, landschapswaarden, duiden op het sociaal-culturele belang dat u aan een specifieke locatie hecht. Wat ik probeer te onderzoeken is met welke waarden toekomstige land en waterbeheer maatregelen rekening moeten houden, en vanaf wanneer deze extra maatregelen acceptabel zijn. Het kan bijvoorbeeld zijn dat een maatregel de belangrijkste waarden beschermt, maar dat betekent niet dat het acceptabel is om deze maatregel nu al in te voeren.

Het invullen van de enquête duurt ongeveer 15 minuten en bestaat uit 18 vragen. Het eerste deel zal gaan over uw huidige situatie. Het tweede deel gaat over de manier waarop u uw boerderij waarde geeft. Deel drie zal gaan over de manier waarop u het natuurgebied de Mariapeel waarde geeft. Het vierde deel gaat over droogte.

De enquête is anoniem. Mocht u interesse hebben in de uitkomsten van het onderzoek dan kunt u aan het einde van de enquête uw e-mail adres achterlaten. Hetzelfde geldt voor wanneer u wilt deelnemen aan een opvolgend interview. Uiteraard zijn beide keuzes niet verplicht. Daarnaast zal uw e-mail adres niet worden gekoppeld aan uw antwoorden.

Mochten er vragen of opmerkingen zijn kunt u me bereiken via marijke.schipper@wur.nl. Mocht u mijn scriptiebegeleider willen spreken, dan kunt u contact met haar opnemen via bregje.vanderbolt@wur.nl.

Alvast bedankt voor uw tijd en moeite.

Met vriendelijke groet,

Marijke Schipper

Uw huidige situatie

1. Bent u man of vrouw:

- ❑ Vrouw
- ❑ Man
- ❑ Anders

2. In welke leeftijdsgroep valt u?

- ❑ 18 – 24
- ❑ 25 – 34
- ❑ 35 – 44
- ❑ 45 – 54
- ❑ 55 – 64
- ❑ 65 – 74
- ❑ 75 – 84
- ❑ 85 en ouder

3. Wat voor soort landbouw beoefent u?

- ❑ Akkerbouw
- ❑ Tuinbouw op een akker
- ❑ Tuinbouw in een kas
- ❑ Veeteelt
- ❑ Anders_____

4. Bent u de eigenaar van de boerderij of huurt u?

- ❑ Huur
- ❑ Eigenaar
- ❑ Anders: ______

<u>De manier waarop u uw boerderij waarde geeft</u>

Omdat het onderzoek gericht is op boeren die werken in de omgeving van de Mariapeel, is het belangrijk dat de volgende vragen worden beantwoord wanneer u denkt aan uw boerderij of het land dat u pacht in de omgeving van de Mariapeel.

5. Hoe belangrijk zijn de volgende waarden voor u als u denkt aan uw boerderij of het land dat u huurt (in de omgeving van de Mariapeel)? Geef alstublieft aan hoe belangrijk of niet belangrijk elke waarde voor u is.

*Bijvoorbeeld: **'Ik vind het mooie landschap, bezienswaardigheden, geluiden en geuren' 'zeer belangrijk'** wanneer ik aan mijn boerderij of het land dat ik huur denk.*

	Zeer belangrijk	Belangrijk	Redelijk belangrijk	Niet erg belangrijk	Helemaal niet belangrijk	Ik weet het niet
Ik vind het mooie landschap, bezienswaardigheden, geluiden en geuren (esthetisch)	☐	☐	☐	☐	☐	☐
Ik vind de verscheidenheid en de overvloed aan vogels / dieren / planten (biodiversiteit)	☐	☐	☐	☐	☐	☐
Ik vind het doorgeven van wijsheid, kennis en tradities (cultureel-historisch)	☐	☐	☐	☐	☐	☐
Om het onderhouden van mezelf en/of mijn gezin en geliefden (economisch)	☐	☐	☐	☐	☐	☐
Ik vind het duurzaam beheren van land voor toekomstige generaties boeren (toekomst)	☐	☐	☐	☐	☐	☐
Ik vind de leefwijze en levensinstelling van een agrariër (identiteit)	☐	☐	☐	☐	☐	☐
Ik vind het gevoel van verbondenheid met de omgeving en/of de gemeenschap (sociale relaties)	☐	☐	☐	☐	☐	☐

Ik vind het kunnen leren van de omgeving (leren)	☐	☐	☐	☐	☐	☐
Ik vind het produceren van lokaal en/of kwalitatief goed voedsel (leven ondersteunend)	☐	☐	☐	☐	☐	☐
Ik vind onze vrijetijdsbesteding hier (recreatie)	☐	☐	☐	☐	☐	☐
Ik vind de heilige, religieuze of diepgaande ervaring (religieus/spiritueel)	☐	☐	☐	☐	☐	☐
Ik vind de stress vermindering, comfort en/of rust (therapeutisch)	☐	☐	☐	☐	☐	☐

6. Zijn er waarden die volgens u in de bovenstaande tabel ontbreken?

Voer hier uw antwoord in

7. Bent u bekend met het natuurgebied de Mariapeel?

❑ Ja
❑ Nee

Het natuurgebied de Mariapeel

8. Hoe belangrijk zijn de volgende waarden voor u als u aan het natuurgebied de Mariapeel denkt?

Vraag 7 en 8 gaan over dit natuurgebied.

Geef alstublieft aan hoe belangrijk of niet belangrijk elke waarde voor u is.
*Bijvoorbeeld: '**Ik vind het mooie landschap, bezienswaardigheden, geluiden en geuren**' '**zeer belangrijk**' wanneer ik aan het natuurgebied de Mariapeel denk.*

	Zeer belangrijk	Belangrijk	Redelijk belangrijk	Niet erg belangrijk	Helemaal niet belangrijk	Ik weet het niet
Ik vind dat iedereen toegang heeft tot het natuurgebied, vrij van beperkingen (toegang)	☐	☒	☐	☐	☐	☐
Ik vind het mooie landschap, bezienswaardigheden, geluiden en geuren (esthetisch)	☐	☐	☐	☐	☐	☐
Ik vind de verscheidenheid en de overvloed aan vogels / dieren / planten (biodiversiteit)	☐	☐	☐	☐	☐	☐
Ik vind het doorgeven van wijsheid, kennis en tradities (cultureel-historisch)	☐	☐	☐	☐	☐	☐
Ik vind dat het geld oplevert voor de regio (economisch)	☐	☐	☐	☐	☐	☐
Ik vind dat toekomstige generaties gezonde, productieve en duurzame natuur te kunnen laten ervaren (toekomst)	☐	☐	☐	☐	☐	☐

Ik vind het gevoel van verbondenheid met de omgeving en/of de gemeenschap (sociale relaties)	☐	☐	☐	☐	☐	☐
Ik vind het kunnen leren van de omgeving (leren)	☐	☐	☐	☐	☐	☐
Ik vind onze vrijetijdsbesteding hier (recreatie)	☐	☐	☐	☐	☐	☐
Ik vind de nieuwe ervaring, heilige, religieuze of diepgaande ervaring (spiritueel/religieus)	☐	☐	☐	☐	☐	☐
Ik vind de stress vermindering, comfort en/of rust (therapeutisch)	☒	☐	☐	☐	☐	☐

9. Zijn er waarden die volgens u in de bovenstaande tabel ontbreken?

Voer hier uw antwoord in

10. Hoe vaak gebruikt u het gebied voor recreatieve activiteiten?

Bijvoorbeeld: wandelen, fietsen, zwemmen.

- ❑ Elke dag
- ❑ Elke week
- ❑ Elke maand
- ❑ Bijna nooit
- ❑ Nooit

Droogte

De volgende vragen gaan over de groeiende droogte en de impact dat dit heeft op uw boerderij.

11. Heeft u ooit last gehad van droogteschade op uw boerderij of het land dat u huurt (in de omgeving van de Mariapeel)?

    ❑ Ja
    ❑ Nee

12. In hoeverre denkt u dat toegenomen droogte in de zomermaanden van NEGATIEVE invloed kunnen zijn op de volgende landschapswaarden voor uw boerderij of het land dat u huurt (in de omgeving van de Mariapeel)?

    Geef alstublieft aan hoe waarschijnlijk of niet waarschijnlijk een droogte een negatieve impact zal hebben op elke stelling. Deze vraag staat los van vraag 5 waar u heeft aangegeven welke waarden u belangrijk zijn als u denkt aan uw boerderij of het land dat u huurt.

    *Bijvoorbeeld: Een droogte heeft '**zeer waarschijnlijk**' een <u>negatieve</u> '**impact op het mooie landschap, bezienswaardigheden, geluiden en geuren.**'*

	Zeer waarschijnlijk	Waarschijnlijk	Waarschijnlijk niet	Zeer onwaarschijnlijk	Weet ik niet
Negatieve impact op het mooie landschap, bezienswaardigheden, geluiden en geuren (esthetisch).	☐	☐	☐	☐	☐
Negatieve impact op de verscheidenheid en de overvloed aan vogels / dieren / planten (biodiversiteit).	☐	☐	☐	☐	☐

Negatieve impact op het doorgeven van wijsheid, kennis en tradities (cultureel-historisch).	☐	☐	☐	☐	☐
Negatieve impact op het onderhouden van mezelf en/of mijn gezin en geliefden (economisch).	☐	☐	☐	☐	☐
Negatieve impact op het duurzaam beheren van land voor toekomstige generaties boeren (toekomst).	☐	☐	☐	☐	☐
Negatieve impact op de leefwijze en levensinstelling van een agrariër (identiteit).	☐	☐	☐	☐	☐
Negatieve impact op het gevoel van verbondenheid met de omgeving en/of de gemeenschap (sociale relaties).	☐	☐	☐	☐	☐
Negatieve impact op de manier waarop we kunnen leren van de omgeving (leren).	☐	☐	☐	☐	☐
Negatieve impact op het produceren van lokaal en/of kwalitatief goed voedsel (leven ondersteunend).	☐	☐	☐	☐	☐
Negatieve impact op de manier waarop we onze vrijetijdsbesteding doorbrengen (recreatie).	☐	☐	☐	☐	☐
Negatieve impact op de heilige, religieuze of diepgaande ervaring (spiritueel/religieus).	☐	☐	☐	☐	☐
Negatieve impact op de stress vermindering, comfort en/of rust (therapeutisch).	☐	☐	☐	☐	☐

13. Neemt u op dit moment al maatregelen om het droogte te voorkomen of te minimaliseren voor (delen van) uw boerderij of het land dat u huurt (in de omgeving van de Mariapeel) en zo ja, welke?

Voer hier uw antwoord in

De laatste vragen gaan ervan uit dat u op basis van uw kennis en ervaring kan inschatten wat voor soort droogte voor u een onacceptabele toekomstige gebeurtenis vormt. De volgende teksten schetsen een beeld van de impact van de droogte tijdens twee verschillende jaren, namelijk 2003 en 2018. Daarentegen kunt u waarschijnlijk zelf het beste inschatten wat voor soort omstandigheden voor u onacceptabel zijn. U kunt dus ook op basis van uw ervaring de vraag invullen.

De zomer van 2003 staat op nummer 10 in de rangorde van de droogste jaren sinds het begin van de metingen. Door de hoge temperaturen en het hoge aantal zonuren was het neerslagtekort dat jaar heel hoog. Veel sectoren op de hoge zandgronden, waaronder de landbouw, waren dat jaar hiervan de dupe. De droogte zorgde namelijk voor hogere kosten dan normaal. De Maas kon maar net genoeg water afvoeren en burgers werden verzocht beperkende maatregelen te nemen.

De zomer van 2018 staat op nummer 5 in de rangorde van de droogste jaren sinds het begin van de metingen. Door de hoge temperaturen en het hoge aantal zonuren was het neerslagtekort dat jaar extreem droog. Ook nu waren de sectoren op de hoge zandgronden de dupe. Bijna alle landbouwbedrijven ondervonden hogere kosten dat jaar, ongeveer twee keer zo veel als in 2003. Daarnaast had de natuur had het zwaar te verduren vanwege uitdroging en natuurbranden. Het natuurgebied de Deurnse Peel had bijvoorbeeld te maken met natuurbranden.

Hieronder vindt u een tabel met de statistieken voor de droogte van 2003 en 2018.

	2003	2018	Normaal
Neerslagtekort (neerslag + verdamping)	234mm	309mm	106mm
Neerslag die zomer	119mm	105mm	202mm
Tropische dag (>30 graden)	11 dagen	8 dagen	3 dagen
Zomerse dag (>25)	40 dagen	55 dagen	18 dagen

14. In welk scenario zou u extra maatregelen overwegen om de gevolgen van deze gebeurtenissen voor uw boerderij of het land dat u huurt (in de omgeving van de Mariapeel) te voorkomen? (U kunt meerdere vakjes aankruisen).

De volgende scenario's zijn berekend door het KNMI.

- ❑ Wanneer het scenario van 2003 eens in de 2 jaar zal voorkomen
- ❑ Wanneer het scenario van 2003 eens in de 3 jaar zal voorkomen
- ❑ Wanneer het scenario van 2003 eens in de 8 jaar zal voorkomen
- ❑ Wanneer het scenario van 2018 eens in de 10 jaar zal voorkomen
- ❑ Wanneer het scenario van 2018 eens in de 15 jaar zal voorkomen
- ❑ Wanneer het scenario van 2018 eens in de 25 jaar zal voorkomen
- ❑ Geen van allen
- ❑ Andere

15. Heeft u in de vorige vraag een scenario in 2003 EN in 2018 aangeklikt?

- ❑ Ja > vraag 16
- ❑ Nee > vraag 18

16. Landschapswaarden kunnen worden aangetast door een droogte.

Spelen de volgende waarden een rol bij uw keuzes in de vorige vraag?

Op basis van uw vorige antwoord is onderscheid gemaakt tussen de verschillende scenario's.

*Bijvoorbeeld: Ik zou extra maatregelen nemen om de negatieve gevolgen voor '**het mooie landschap, bezienswaardigheden, geluiden en geuren**' op de boerderij te voorkomen ' **alleen voor het 2003 scenario**'.*

	Nee	Ja, maar alleen voor het 2003 scenario	Ja, maar alleen voor het 2018 scenario	Ja, voor het 2003 en het 2018 scenario
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het mooie landschap, bezienswaardigheden, geluiden en geuren te voorkomen (esthetisch).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de verscheidenheid en de overvloed aan vogels / dieren / planten te voorkomen (biodiversiteit).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het doorgeven van wijsheid, kennis en tradities te voorkomen (cultureel-historisch).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het onderhouden van mezelf en/of mijn gezin en geliefden te voorkomen (economisch).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het duurzaam beheren van land voor toekomstige generaties boeren te voorkomen (toekomst).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de leefwijze en levensinstelling van een agrariër te voorkomen (identiteit).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het gevoel van verbondenheid met de omgeving en/of de gemeenschap te voorkomen (sociale relaties).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor onze vrijetijdsbesteding te voorkomen (recreatie).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de heilige, religieuze of diepgaande ervaring te voorkomen (spiritueel/religieus).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de stress vermindering, comfort en/of rust te voorkomen (therapeutisch).	☐	☐	☐	☐

Ik zou extra maatregelen nemen om de negatieve gevolgen voor het mooie landschap, bezienswaardigheden, geluiden en geuren te voorkomen (esthetisch).	☐	☐	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de verscheidenheid en de overvloed aan vogels / dieren / planten te voorkomen (biodiversiteit).	☐	☐	☐	☐

17. Heeft u een aanvulling op uw antwoorden bij de vorige vraag? Waarom zijn juist deze landschapswaarden belangrijk bij uw beslissing?

Voer hier uw antwoord in

18. Landschapswaarden kunnen worden aangetast door een droogte. Spelen de volgende waarden een rol bij uw keuzes in de vorige vraag?

Bijvoorbeeld: Wanneer '**het scenario van 2018 eens in de 10 jaar zal voorkomen**' zou ik extra maatregelen nemen om de negatieve gevolgen voor '**het mooie landschap**' op de boerderij te voorkomen.

	Ja	Nee
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het mooie landschap, bezienswaardigheden, geluiden en geuren te voorkomen (esthetisch).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de verscheidenheid en de overvloed aan vogels / dieren / planten te voorkomen (biodiversiteit).	☐	☐

Ik zou extra maatregelen nemen om de negatieve gevolgen voor het doorgeven van wijsheid, kennis en tradities te voorkomen (cultureel-historisch).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het onderhouden van mezelf en/of mijn gezin en geliefden te voorkomen (economisch).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het duurzaam beheren van land voor toekomstige generaties boeren te voorkomen (toekomst).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de leefwijze en levensinstelling van een agrariër te voorkomen (identiteit).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het gevoel van verbondenheid met de omgeving en/of de gemeenschap te voorkomen (sociale relaties).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor onze vrijetijdsbesteding te voorkomen (recreatie).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de heilige, religieuze of diepgaande ervaring te voorkomen (spiritueel/religieus).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de stress vermindering, comfort en/of rust te voorkomen (therapeutisch).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor het mooie landschap, bezienswaardigheden, geluiden en geuren te voorkomen (esthetisch).	☐	☐
Ik zou extra maatregelen nemen om de negatieve gevolgen voor de verscheidenheid en de overvloed aan vogels / dieren / planten te voorkomen (biodiversiteit).	☐	☐

19. Heeft u een aanvulling op uw antwoorden bij de vorige vraag? Waarom zijn juist deze landschapswaarden belangrijk bij uw beslissing?

Voer hier uw antwoord in

Afronding

20. Alhoewel een enquête een handig middel is om snel informatie te krijgen, zou het een meerwaarde hebben voor de uitkomsten van het onderzoek als u nog een interview van ongeveer 15 - 20 minuten zou willen doen. Mocht u interesse hebben in een interview dan kunt u uw e-mail adres of telefoonnummer hieronder invullen. Uw gegevens zullen niet worden gekoppeld aan de antwoorden in de enquête. Het interview kan zowel anoniem als niet anoniem, afhankelijk van uw voorkeur.

Voer hier uw antwoord in

21. Mocht u interesse hebben in de uitkomsten van het onderzoek, dan kunt u uw e-mail adres hieronder invullen. Uw gegevens zullen niet worden gekoppeld aan de antwoorden.

Voer hier uw antwoord in

ANNEX B

LANDSCAPE VALUES RATIONALE

The research adopted the initial list of landscape values from Ramm et al. (2017) (Table C.1.). While more researchers have identified landscape values (Gregory Brown, 2006; Novaczek et al., 2011; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013; Tyrväinen, Mäkinen, & Schipperijn, 2007), the reason for using this particular list is two-fold. First, the list tailors specifically to climate adaptation management. Therefore, it was designed to understand the risk of climate change for a local vision. Second, the researcher included the list and definitions of the values in the supplementary data, making it easy to access.

The drawback of the initial list is that the researchers made a list for public places and everyone living in the region. When designing a list of landscape values for a particular sub-group of the population, one must keep in mind that not all values may apply. For instance, the 'access' value is not applicable for farmers when asking for their property because it is not public property. Furthermore, because the list tailors to the whole population, it still needed to be adapted to the sub-group. Therefore, a preliminary literature review was conducted to understand which landscape values are important to farmers.

The preliminary review gathered that several important landscape values were missing, such as the importance of a rural lifestyle and the relationship with the local community, as identified by Raymond, Bieling, et al. (2016). While somewhat wrapped within the value 'Identify/symbolic', it was chosen to split this value into two separate values that highlighted the importance of 1) the community and 2) the farmer's identity. Moreover, the definition of the 'future' landscape value was altered to incorporate the importance of looking after the land for future generations (Busck, 2002; Raymond, Bieling, et al., 2016). The review altered the economic value to include the importance of a profitable company to support themselves and their families. The life-sustaining value is changed to incorporate the importance of producing local and high quality food (Raymond, Bieling, et al., 2016).

The rest of the definitions were slightly altered, given that the initial definitions were somewhat abstract and difficult to understand. Various acquaintances who did not have any prior knowledge on landscape values tested the list to ensure clear and comprehensible language. The differences between the names and definitions of the landscape values can be seen below in Table B.1.

Table B.1. The landscape values and corresponding definitions in this study as compared to the initial list of values by Ramm et al. (2017).

Landscape value	Definition in the survey	Landscape value by (Ramm et al., 2017)	Definition by Ramm et al. (2017)
Aesthetic	I value this place for the beautiful scenery, sights, sounds and smells	Aesthetic	I value these places for the enjoyable scenery, sights, sounds and smells.
Biodiversity	I value this place for the variety and abundance of birds / animals / plants	Biodiversity	I value these places for the variety and abundance of fish, birds, wildlife and plant life.
Cultural-historical	I value this place for passing on wisdom, knowledge and traditions (cultural-historical)	Cultural	I value these places for passing down wisdom, knowledge and traditions.
Economic	I value this place because it supports myself and / or my family and loved ones	Economic	I value these places for tourism, fisheries (commercial/recreational) and other business.
Future	I value this place because it provides sustainable land management for future generations of farmers	Future	I value these places because future generations can know and experience healthy, productive, and sustainable ecosystems.
Identity	I value this place for the lifestyle and lifestyle of a farmer	Identify/symbolic	I value these places because they engender a sense of place, community and belonging.
Social Relations	I value this place for the feeling of belonging to the environment and / or the community	Identify/symbolic	I value these places because they engender a sense of place, community and belonging.
Learning	I value this place for being able to learn from the environment	Learning	I value these places for the educational value.
Life-sustaining	I value this place for producing local and / or good quality food	Life sustaining	I value these places because they help produce, support and preserve human and natural life.

Recreation	I value this place our leisure time here	Recreation	I value these places because they provide outdoor recreation activities.
Religious/spiritual	I value this place for the sacred, religious or profound experience	Spiritual / novel experience	I value these places as sacred, religious, unique, and/or profound experiences where respect for nature is felt.
Therapeutic	I value this place for the stress reduction, comfort and / or rest	Therapeutic	I value these places because they enhance feelings of wellbeing (an escape, stress relief, comfort and calm).
(Access)	I value this place because everyone has access to the nature reserve, free of restrictions (only visible for the Mariapeel question)	Access	I value these places because they are common property, free from access restrictions of exclusive ownership/control.

ANNEX C

The interviews started with the purpose of the research and ensuring confidentiality. Next, the interview asked questions on their characteristics, including their link with the region, what they find important about their land, what they find important about the Nature2000 area, and lastly, about the increase in droughts. The interviews took approximately between 20 and 60 minutes. Table C.1 introduces the interviewed farmers. The section below presents the interview transcript.

Table C.1. *List of interviewed farmers.*

Name
Jan Classens
Ton van Herpen
Mark Pijnenborg

Interview transcript.

[*Bedanken, voorstellen, herhalen scriptie & WUR*]

Dit onderzoek is gebaseerd op het idee dat wanneer land en waterbeheer maatregelen de waarden van boeren zo veel mogelijk beschermen, er dan ook een groter draagvlak komt voor deze maatregelen. Wat ik probeer te onderzoeken is met welke belangen toekomstige maatregelen rekening moeten houden, en vanaf wanneer deze extra maatregelen acceptabel zijn. Dit deel van het onderzoek gaat er dan ook over wat agrariërs belangrijk vinden in hun werk en de plek waar ze wonen. De verwachting is dat het interview ongeveer 15 tot 20 minuten duurt.

Voordat we beginnen moet ik nog een paar vragen aan u stellen. Mijn eerste vraag is of ik uw inzichten mag gebruiken en verwerken in mijn verslag?

Daarnaast is op basis van uw voorkeur het interview wel of niet anoniem. In beide gevallen is het mogelijk dat mijn scriptiebegeleider van de universiteit het uitgewerkte interview wil inzien. Uw anonimiteit wordt dan uiteraard ook gerespecteerd. Mijn tweede vraag is dus of u met naam of anoniem in het verslag wil?

[*Wanneer met naam in het verslag*] Had u ook de conceptversie van het eindverslag willen lezen?

Uw antwoorden zijn belangrijk voor het onderzoek, dus ik zal tijdens het gesprek aantekeningen maken. Om er zeker van te zijn dat mijn aantekeningen kloppen, zou ik ook graag een geluidsopname maken. De opname is vertrouwelijk en wordt niet met anderen gedeeld. Heeft u daar een bezwaar tegen?

[*hier wel of niet de start van de audio*]

Dan kunnen we beginnen met het stellen van de vragen.

1. Om het nog even op audio te bevestigen, u heeft geen bezwaar met deze geluidsopname?

2. Wat voor soort landbouw beoefent u?

3. Hoe lang werkt u al in de omgeving van de Mariapeel? En woont?

4. Bent u eigenaar van uw boerderij waar u werkt of huurt u?

De volgende vragen gaan over wat u belangrijk vindt aan uw boerderij en aan de omgeving.

5. Wat vindt u belangrijk aan uw werk, en uw boerderij?

6. Wat vindt u belangrijk aan de omgeving? (Mariapeel)

Droogte

De volgende vragen gaan over droogte.

7. Heeft u ooit last gehad van droogteschade op uw boerderij of het land dat u huurt?
    a. [*Antwoord: Ja, zie vraag 8 tot en met 10*]
    b. [*Antwoord: Nee, zie vraag 11 tot en met 13*]

8. Wanneer was dit?

9. Wat voor impact had dat voor uw werkzaamheden?

10. Bij welke frequentie van dit soort droogte zou u overwegen om (extra) maatregelen te nemen om uw boerderij te beschermen?

11. Kunt u voor mij een hypothetisch scenario bedenken wanneer een droogte ervoor zorgt dat het uw werkzaamheden en manier van leven op zo'n manier inperkt dat u zou overwegen om maatregelen te nemen?

12. Wat voor impact zou dit hebben?

13. Bij welke frequentie van dit soort droogte zou u overwegen om maatregelen te nemen om uw landgoed te beschermen?

14. Denkt u de toegenomen droogte van invloed kunnen zijn op wat u heeft aangegeven als belangrijk voor uw landgoed of het landgoed dat u huurt?

15. Zou u ook waterbesparende maatregelen nemen wanneer de belangen die u heeft genoemd voor de Mariapeel in gevaar komen door een groeiende droogte?

16. Zijn er nog specifieke belangen die hierbij een rol spelen?

17. Waarom juist deze belangen?

Afronding

18. Heeft u ook behoefte om de uitkomsten van het onderzoek te zien?

19. Ik werk het interview uit. Ik zou het uitgewerkte interview naar u kunnen sturen zodat u kan controleren dat ik alles juist en volledig heb opgeschreven. Had u dit gewild?

20. Heeft u verder nog vragen voor mij?

21. Kent u toevallig ook meer agrarische ondernemers in de omgeving van de Mariapeel die bereid zouden zijn de survey in te vullen?

ANNEX D

CODING LOG

Thematic coding works as follows (Gibson & Brown, 2009). When reading the interview, a code is created based on the relevance of the aim of the interview method. Each code is described by its relevance to the interviews' aim. Coding is a cyclical process; the codes change, once more interviews were read. Suppose necessary, codes can be split or merged. Once the researcher creates the codes, the data is ready for the following step: creating coding families. This is not the same as merging code. Creating coding families is the process of grouping codes that have similar features. The coding families are subsequently revised based on whether they are helpful for the aim and an accurate representation of the data in the interviews. Similar to the codes, the coding families are given a description. Finally, the results are described. This includes how often a theme appeared, what is meant by the code and illustrations from the interviews to underline the argument.

Several codes were used initially but eventually split because the code was not specific enough to reflect the information in the interview. For instance, the coding family 'importance of farm' was previously used as a code but now split up into several more specific codes that can better reflect the type of value farmers place on their farm. The same was done for the coding families 'importance of the surrounding area' and 'importance of the nature area'. Moreover, the code 'tensions because of nature' was split into two codes 'tensions because of nature' and 'tensions because of administrative rules'. While the two are intertwined, some essential differences needed to be analysed distinctively.

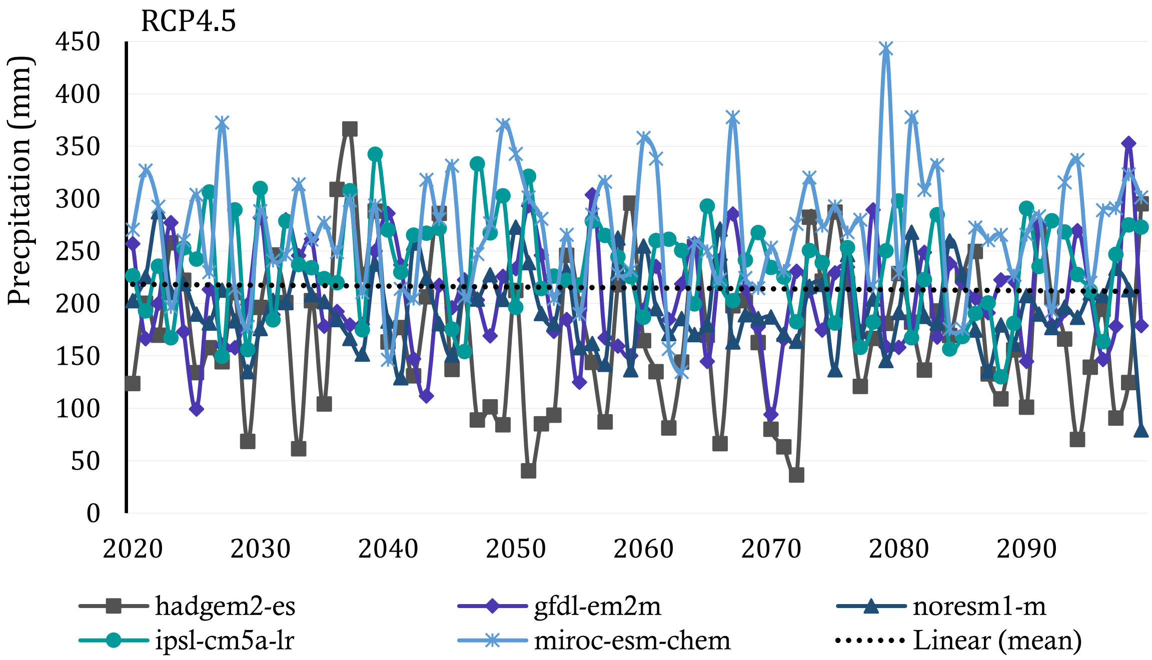
Table D.1. *The coding families, corresponding codes and descriptions following the interviews.*

Coding family	Code	Description
Background information	Type of farmer	Types of farming practised by the interviewees
	Years of working	Amount of years working in the area, link with area
	Owner of the company	Owner or tenant of the company in the area
Importance of farm	To do business	Being able to do their work without too many restrictions
	Aesthetic value	Having a neat and aesthetically pleasing company and agricultural land
	Laws and regulations	Adhering to the laws and regulations
	Future of the business	Being able to do the same work in the future

	Quality of the work	Taking good care of the land, animals and deliver good quality work
	Job satisfaction	A sense of fulfilment and happiness from working
Importance of the surrounding area	Social interactions	Interactions with neighbours and community
Importance of Nature 2000 area	Conservation	Conserve the nature area for future generations
	Interaction nature and agriculture	Being able to work together
	Recreation	The area serves a role for recreation and tourism
	Aesthetic	It enhances the aesthetic worth of the region
Times of drought		When did the drought occur
Limiting drought		Measures farmers take to prevent the impacts of drought
Problems because of drought	Mental problems	The stress it gives farmers
	Physical problems	Droughts cost much energy
Tensions	Tensions with the Nature2000 area	The problems arising from living close to this area
	Tensions because of administrative rules	Restrictions from the water authority during times of drought

ANNEX E

Precipitation development



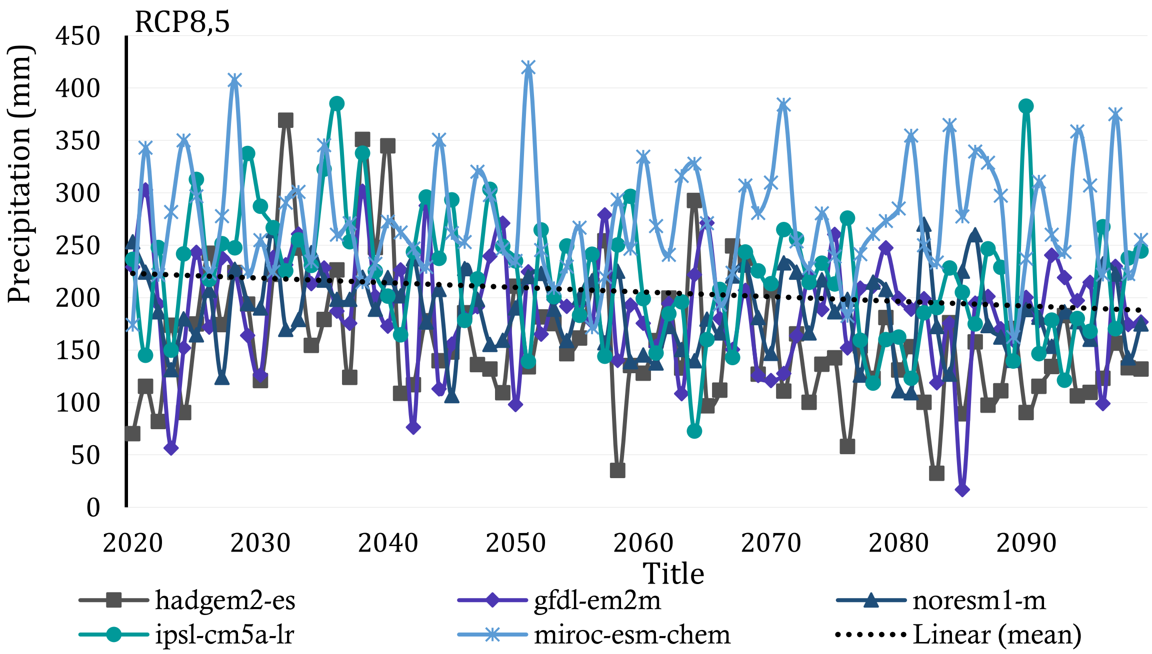


Figure E.1. *Development of yearly precipitation in the months June, July and August for RCP4.5 (top) and RCP8.5 (bottom) in the Mariapeel, Limburg.*

Precipitation trends in the Mariapeel

Precipitation is a deciding factor for drought according to the KNMI (Sluijter et al., 2018). The development of the yearly summer precipitation is therefore an integral part of this analysis. As can be seen from Figure E.1, changes in precipitation are extremely volatile and uncertain to predict instead for instance temperature (E.2). A steady decrease in precipitation can be seen for RCP8.5.While a downward trend can be seen in Figure E.1 (bottom), the different climate models disagree on how much rainfall will decrease.

Nevertheless, the steady decrease does imply an increase in dryer summer months, and therefore more extremes towards the end of the century. While RCP4.5 is very fluctuating, there is no clear trend down or upward. What can also be gathered from the figures is that some models such as hadgem2-es predict much less rainfall in the future while the miroc-esm-chem model predicts more rainfall in the future. The profound differences in models make that the precipitation projections should be approached with caution.

Temperature development

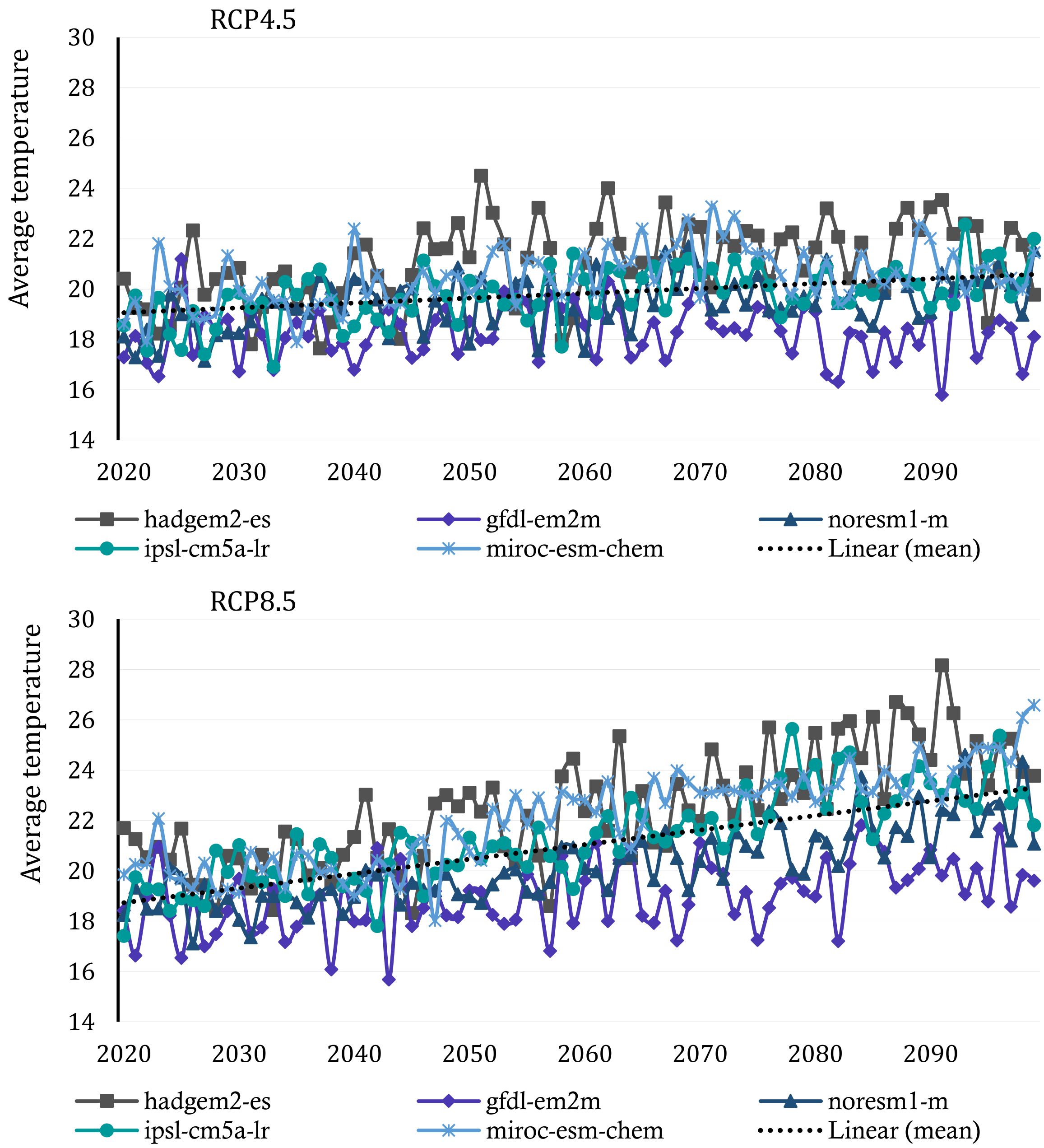
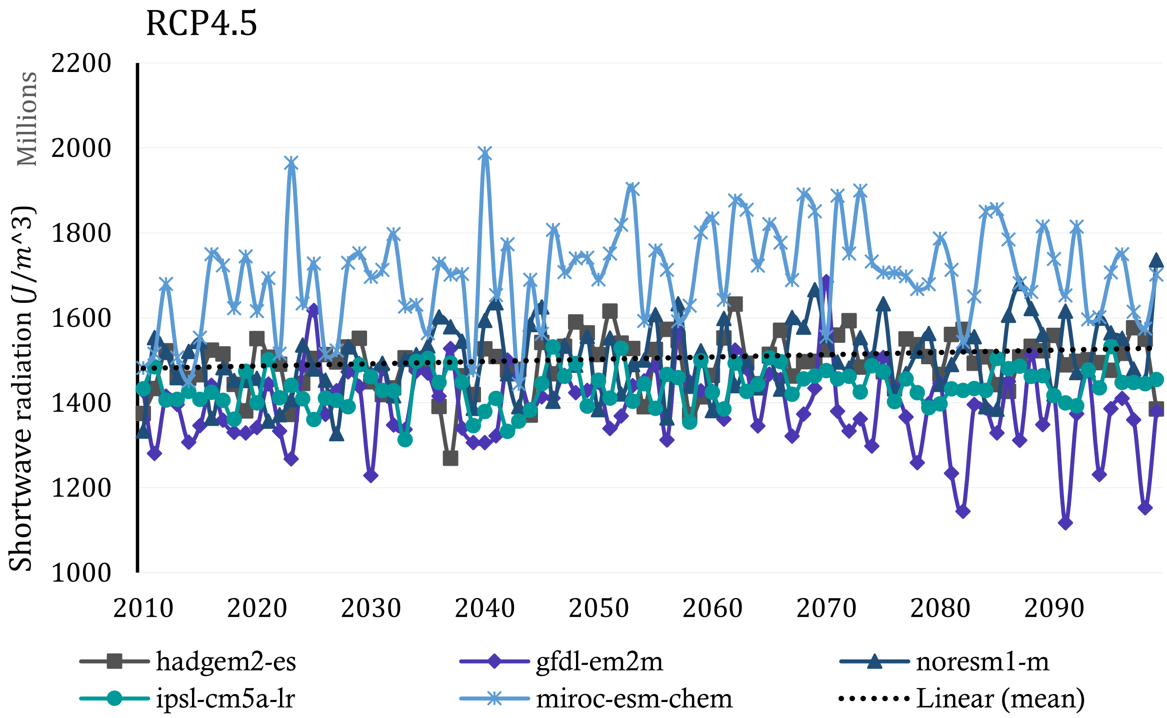


Figure E.2. *Development of yearly temperature in the months June, July and August for RCP4.5 (top) and RCP8.5 (bottom) in the Mariapeel, Limburg.*

Temperature trends

As can be seen in Figure E.2, average temperature in the summer months of June, August and September will see an increase towards the end of the century. Particularly, under the RCP8.5 scenario there is a steady rise in temperature. The models under RCP4.5 show a moderate trend upward. The variance between the models for both models is clearly visible. The variance is not too large at the beginning of the century, yet it gets larger further into the century. Nevertheless, the upward trend is clearly visible. Average temperature during the summer is important because it is an important factor in evapotranspiration. The higher the temperature in summer, the more evaporation. The more evaporation, the larger the precipitation deficit.

Shortwave radiation development



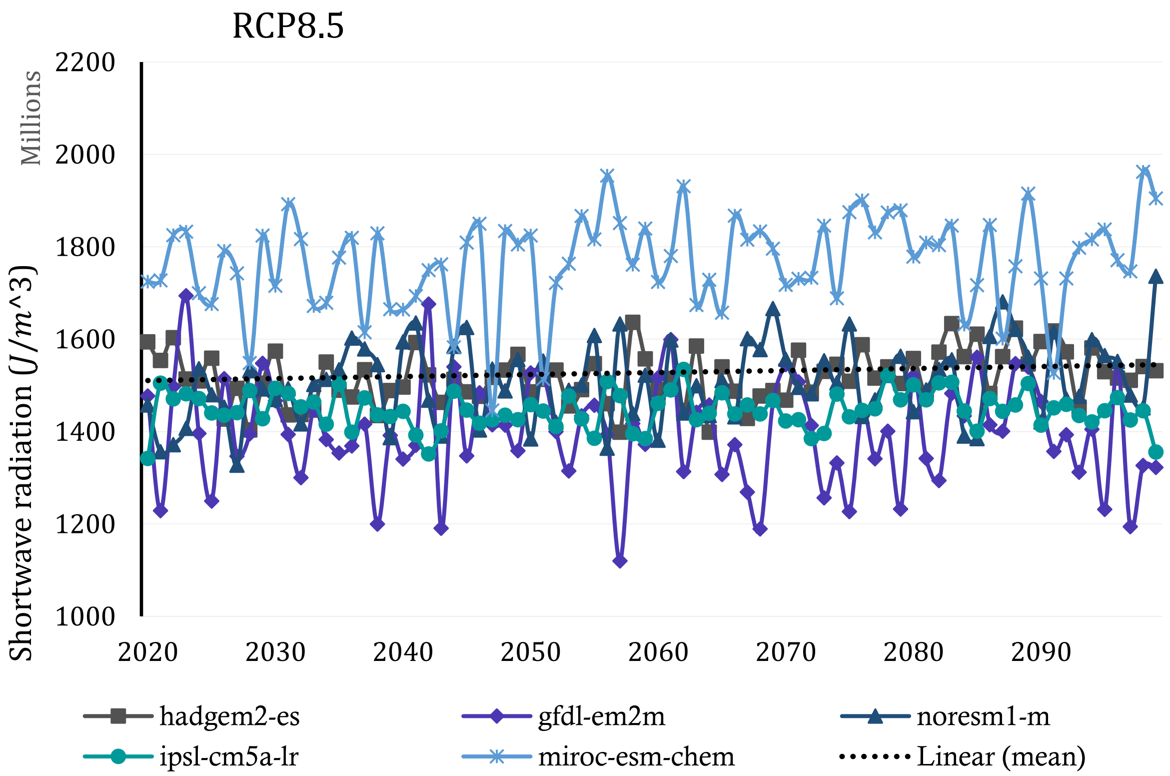


***Figure E.3.** Development of yearly shortwave radiation in the months June, July and August for RCP4.5 (top) and RCP8.5 (bottom) in the Mariapeel, Limburg.*

Shortwave radiation trends in the Mariapeel

As can be derived from the figures, shortwave radiation is expected to increase slightly. This change, however, is not clearly visible. What can be noted when comparing the two figures is that the climate models do not differentiate as much from one another in RCP4.5 compared to RCP8.5. For RCP8.5 the differences are greater. In addition, miroc-esm-chem expects the shortwave radiation to spike, much more so compared to the other climate models. Gfdl-em2m, on the other hand, predicts much lower shortwave radiation, particularly towards the end of the century. Shortwave radiation predictions come with high uncertainties and should be approached with caution.

Precipitation deficit development

The previous climatic variables were put into the Makkink equation. The equation derived the following results under RCP4.5 and RCP8.5. The graphs are split up in time ranges [2020-2049; 2050-2079; 2080-2099].

RCP4.5

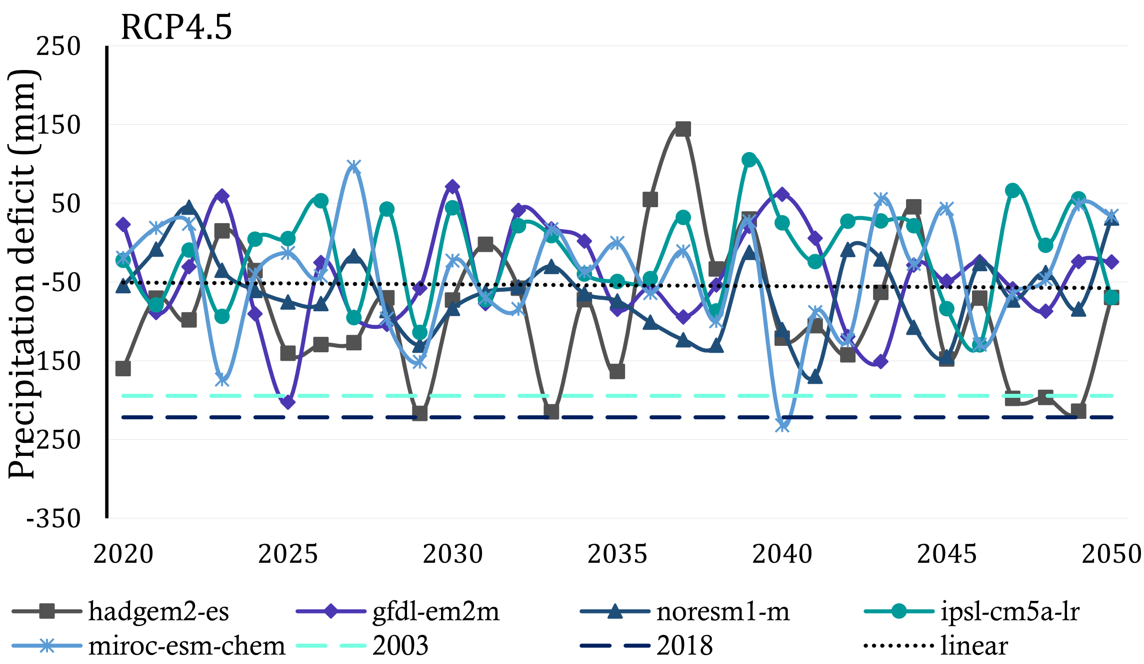


Figure E.4. *Development of yearly precipitation deficit in the months June, July and August for RCP4.5 in the Mariapeel, Limburg.*

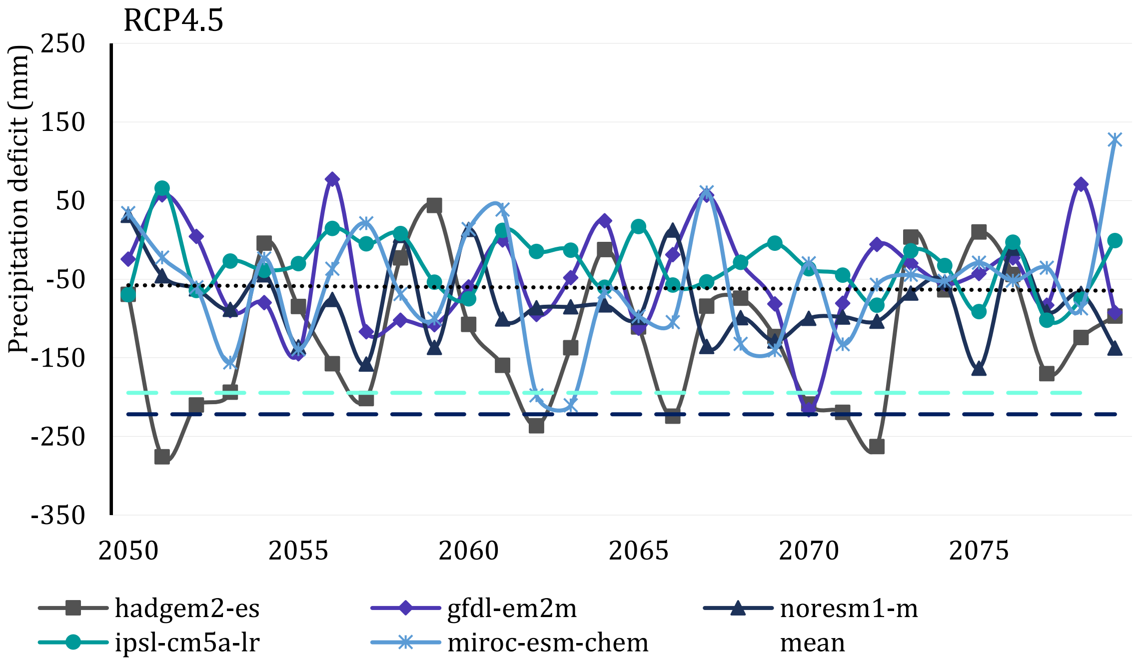


Figure E.5. *Development of yearly precipitation deficit in the months June, July and August for RCP4.5 in the Mariapeel, Limburg.*

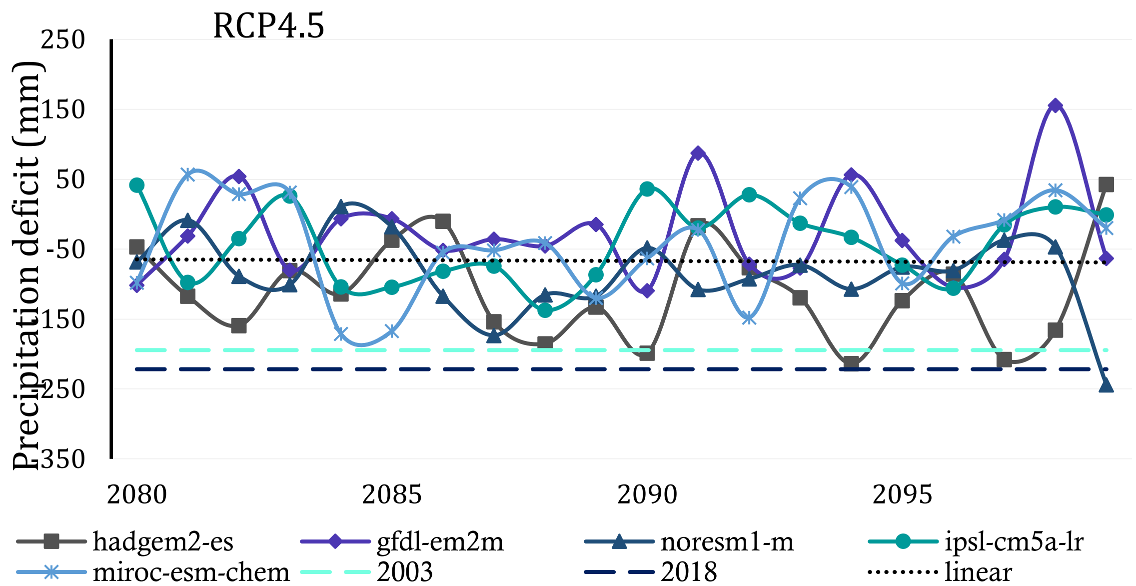


Figure E.6. *Development of yearly precipitation deficit in the months June, July and August for RCP4.5 in the Mariapeel, Limburg.*

RCP8.5

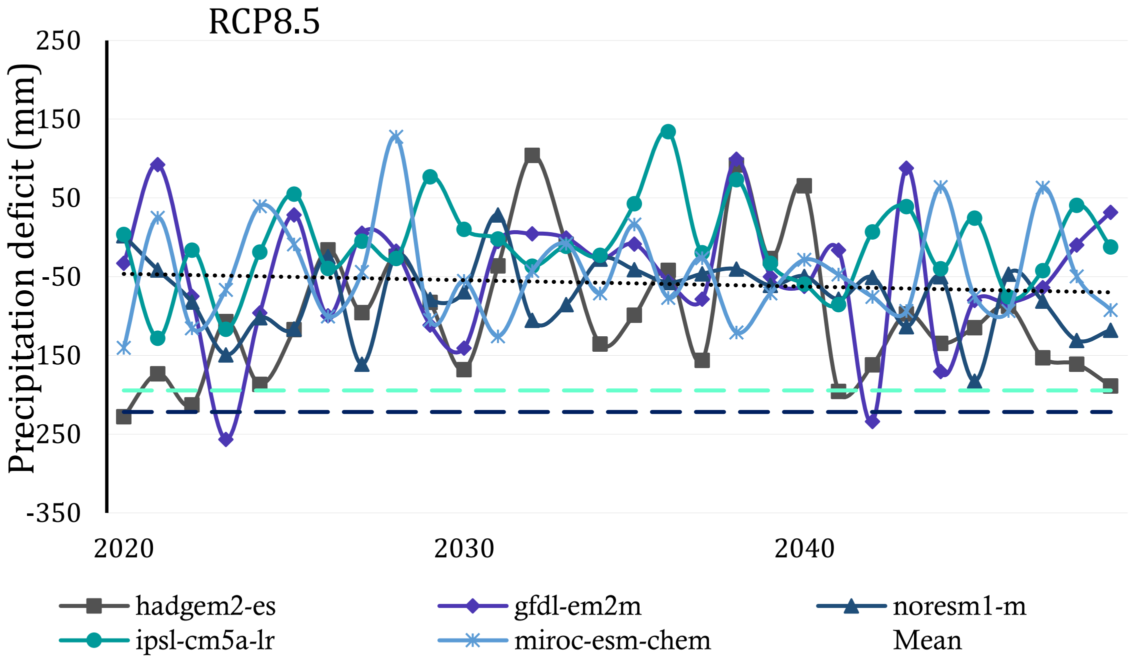


Figure E.7. *Development of yearly precipitation deficit in the months June, July and August for RCP8.5 in the Mariapeel, Limburg.*

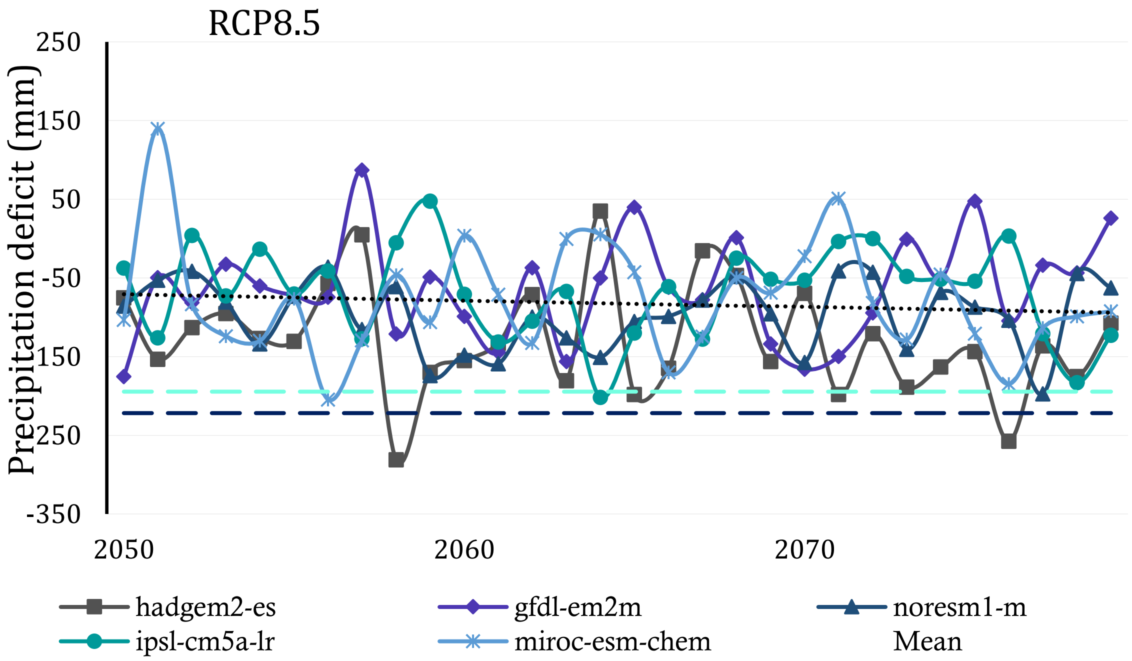


Figure E.8. *Development of yearly precipitation deficit in the months June, July and August for RCP8.5 in the Mariapeel, Limburg.*

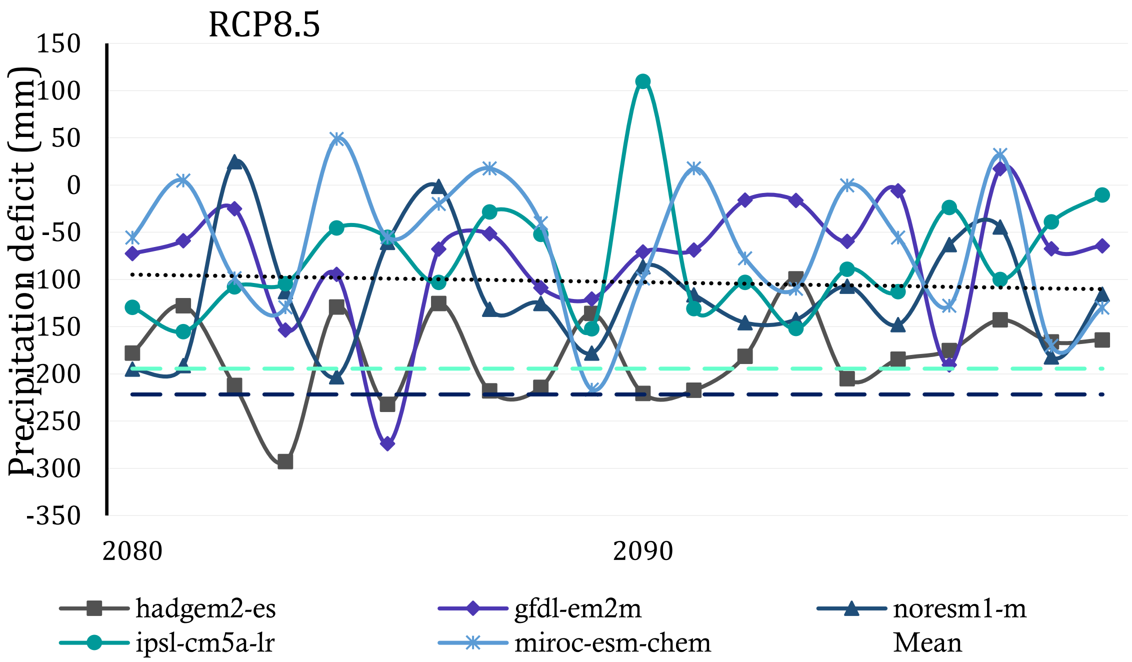


Figure E.9. *Development of yearly precipitation deficit in the months June, July and August for RCP8.5 in the Mariapeel, Limburg.*

ANNEX F

Rationale Table 6.1

The following paragraphs describe the rationale behind the estimated benefit or harm to the top-rated landscape value. It is necessary to note that this was done superficially with many assumptions mase. The section below will go into more detail on the methodology.

Table F.1. *A way to rate LIWA measures against the most frequently mentioned important landscape values, as adapted from Ramm et al. (2018).*

	Estimated benefit or harm to top-rated landscape values [1]					
LIWA measures	Economic	Future	Identity	Life-sustaining	Relative costs to farmers [2]	Time to benefits
Sub-irrigation[3]	+	++	±	++	€€	Short
Soil infiltration	±	++	±	++	€	Long
Reservoirs at summer level	±	++	+	+		Short

[1] '±' either small benefit or harm; '+' small benefit; '++' large benefit
[2] Initial investment costs
[3] Based on the knowledge there is now, specifically from LIWA and a pilot project in the Peel.

How are the values translated into more tangible criteria for measures?

Because landscape values can convert into an adaptation objective, the objectives can qualitatively assess adaptation pathways or measures. Based on the interviews and the literature on landscape values, the meaning behind the values translates into more tangible criteria. The economic value is translated into how the measure affects the company's revenues; this value is relatively short-term because the farmer must make revenues each year for a decent living. The future value translates into how the measure affects the water availability for future generations under drought. This is a long-term value. The identity value focuses on how the measure impacts job satisfaction and disrupts normal working activities, also a short-term value. The life-sustaining value looks at how the measure affects the quality of the land and the food that is grown, a long term value.

Sub-irrigation

With surface irrigation, water losses occur due to drift and evaporation. With sub-irrigation, this occurs less. This can be done from both surface and groundwater (Waterschap Limburg, 2020). The drawback of the measure is that it is time costly and complex, especially if the subirrigation system has to cover a lot of ground (Lievese CSO, 2018). There are also higher investment costs. The advantages are that the farmer has to irrigate less, no water withdrawal permit is needed, winter precipitation surplus can be used in summer, there is less leaching of nutrients and higher crop yields (Lievese CSO, 2018).

How does this translate to the estimated benefit or harm to the landscape values?

Economic value: While there are initial investments costs and management costs, possible higher crop yields and less expensive irrigation can contribute to higher gains. It must be noted that there is still a lot of research being done on the efficacy of sub-irrigation (Waterschap Limburg, 2020). It is not always clear whether sub-irrigation actually leads to higher crop yields. Therefore, the benefit to the economic value is a small benefit, rather than a large benefit. This may change with more research.

Future value: If all benefits reaped from the pilot projects hold true in practice, the measure will contribute to a sustainable farm for future generations. Even during droughts this system will enable the farmer to harvest.

Identity value: It is unknown whether a sub-irrigation measure will contribute to the job satisfaction of the farmer and the continuation of the work. The reason for this is that the irrigation system can be very complex, and it costs a lot of time to control it. This technology may become easier in time, but for now the benefit is unknown.

Life-sustaining value: If all benefits reaped from the pilot project work in practice, the measure will contribute to the quality of the land and the food, especially during summertime. More water in the ground and less runoff of nutrients means more productive and healthy soils and therefore better quality food.

Soil infiltration

By changing the tillage and increasing the organic matter content in the soil, infiltration in the soil increases (Waterschap Limburg, 2020). It is unclear how the waterboard or the researchers behind LIWA intend this to happen, but further research indicates the following options: optimization of crop rotation, leaving crop residue on land, prevention of set-aside, and the (complete) reduction of tillage (Wösten & Groenendijk, 2019). The drawbacks are the investment costs and energy the farmers have to give to implement this measure (Wösten & Groenendijk, 2019). In addition, the benefits will only be reaped in the long-term. Increasing soil organic matter content takes a long time. The advantages of this measure, albeit in the long-run, are that the soil can retain more water and it reduces surface run-off. It must be noted here that the advantages and disadvantages are based on measures published by STOWA, knowledge centre of the regional water managers, including the waterboards. It is thus not clear whether the waterboard of Limburg actually intends to implement these measures.

How did this translate to the estimated benefit or harm to the landscape values?

Economic value: Because the measure will likely only bear fruit in the long term, it is unknown whether the economic value gains or losses.

Future value: As for future value, this is an excellent measure for the sustainable management of the land for future generations.

Identity value: It is unknown whether these soil infiltration measures will contribute to the job satisfaction of the farmer and the continuation of the work. Especially because the measure only bears fruit in the long-term, it can be a lot of work and effort to implement in the years where no/little benefits are seen. For now the benefit is unknown.

Life-sustaining value: While only in the long-run, the increase in soil organic matter does increase the quality of the land and in turn the food produced.

Reservoirs at summer level

The reason for this measure is that the water supply accumulates in the winter and quickly disappears in the spring, mainly because of the lower surface water levels (Waterschap Limburg, 2020). When the farmer puts the water level at 50 cm below ground level or higher year-round, a larger water supply is created in during the winter, so that in spring there is a need for later and less irrigation. The drawback of this measure is the potential flooding in winter and spring, which can cause wet damage (Waterschap Limburg, 2020). The advantages are that less irrigation is required in the spring, which can continue into the summer months. The measure contributes to system recovery of the ground and surface water regime and a resilient water system into the future. Another benefit of this measure is that the initial investments costs are very low because this measure merely needs level-controlled drainage, already a mandatory installation for farmers.

How did this translate to the estimated benefit or harm to the landscape values?

Economic value: Because of the potential wet damage it is unknown whether the economic value benefits or harms. On the other hand, if the farmer needs to irrigate less, it can really save costs, which can add to the company's revenues, hence, the unknown character. The measure does benefit the future value.

Future value: It is a very sustainable measure, especially if it does contribute to system recovery of the ground and surface water regime and a resilient water system into the future.

Identity value: Because farmers need to irrigate less, it can contribute to the continuation of their normal work. Less irrigation also costs less mental and physical energy contributing to the job satisfaction. On the other hand, the extra monitoring for wet damage does make it a smaller benefit.

Life-sustaining value: Setting reservoirs at summer level can already quickly provide benefits for the quality of the land and food that is produced. Potential wet damage to the land and the food does make it a smaller benefit.