# All crops need something

*The influence of drought experience on the implementation of sustainable water management into agricultural practices among dairy farms in Salland, the Netherlands*

By

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**Abstract**

The Netherlands is predicted to face more severe and frequent droughts due to climate change. Farmers use over 60% of the land in the Netherlands and are highly reliant on water. This thesis investigates how farmers' decisions to implement sustainable water management practices are influenced by experience with drought. For this purpose, a literature review was conducted to identify the factors that affect farmers' decision-making and to gather expectations about the relationship of drought experience with these factors and the implementation of sustainable water management practices. A qualitative study was designed in the form of semi-structured interviews and document analysis to investigate the relationship between the identified factors. The Salland region was selected for the empirical study, as farmers in this region have different experiences with drought due to geomorphological differences within Salland.

I found that drought experience impacts several factors that are important in the farmer decision making process, especially on internal and external adaptive capacity. How former experience impacts these factors is related to former (mal)adaptation by farmers. Furthermore, it was found that experience of more severe, or frequent droughts resulted in higher risk perception and more drought resilient implementation of sustainable water management practices. There was furthermore found that the inability of the water authority to reduce drought damage to individual farmers can negatively affect the farmers' perception of the authority, and that the institutional setting is hindering drought adaptation.

Six future research directions are identified. First, there should be tested if mal-adaptation is indeed the intervening factor between drought experience and internal and external adaptive capacity. Second, quantitatively testing the frequent proposed relationship between drought experience and SWMP implementation, can enhance the applicability of the framework to other regions and countries. Third, there should be researched when vast investments into true drought resilience are made, as currently none of the adaptations has succeeded in making farmers truly drought resilient. Fourth, the implications of dividing external adaptive capacity into hard to change dimensions, and easily changed dimensions on its relationship with the other proposed factors should be researched. Fifth, prioritisation between transition pathways can likely be included in a farmers' decision models, the impact of this factor should be researched. Sixth, the results of the negative stance towards the water authority are also worth investigating, as it could lead to regime resistance and hinder adaptation efforts.

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**List of Abbreviations and Acronyms**

| | |
|---|---|
| BMS | Faculty of Behavioural, Management and Social sciences |
| CBS | Dutch central statistics office |
| DAW | Deltaplan Agricultural Water management |
| DRM | Disaster-risk management |
| FDDEF | Farmer Decision under Drought Experience Framework |
| IAC | Internal adaptive capacity |
| IIDE | Insignificant, Infrequent drought experience |
| IFDE | Insignificant, frequent drought experience |
| LEI | Agricultural Economics institute |
| LTO | Dutch Agricultural and Horticultural Organisation |
| MIWM | Ministry of Infrastructure and Water Management |
| MLNV | Ministry of Agriculture, Nature and food quality |
| MPACC | Model of Proactive Adaptation to Climate Change |
| NOS | Dutch Broadcasting Foundation |
| OECD | Organisation for Economic Co-operation and Development |
| POP3 | Agricultural development programme |
| PSRM | Pressure State Release Model |
| RIVM | Dutch National Institute of Public Health and the Environment |
| RVO | Netherlands Enterprise Agency |
| SFDE | Severe, Frequent drought experience |
| SIDE | Severe, Infrequent drought experience |
| SDGs | Sustainable development goals |
| SWMP | Sustainable Water Management Practices |
| UN | United Nations |
| UNCCD | United Nations Convention to Combat Desertification |
| UNODRR | United Nations Office for Disaster Risk Reduction |
| WDOD | Water authority Drents Overijsselse Delta |
| ZON | Freshwater availability East Netherland |
| ZLTO | Southern Agricultural and Horticultural Organisation |

# 1. Introduction

## 1.1 Background

Climate change is an issue that has global recognition. The effects of climate change, including more frequent and severe droughts, are already notable. Indeed, the United Nations Convention to Combat Desertification [UNCCD] (2022) stated several global impacts of drought in the last decades, among which: global economic losses of roughly 114.5 billion euros between 1998 and 2017; and since 2000, both the frequency and number of drought events has risen by 29%. Santini et al., (2022) have shown that these droughts have a consistent, negative effects on crop yield of crops needed to provide food and feed (e.g., wheat, maize, soybean). These droughts can therefor lead to worldwide food-shortages and therefore pose a threat to the second sustainable development goal of the United Nations [UN], namely, no hunger globally. Even if further climate change is halted, it is necessary to adapt to the results that are already unfolding. Although droughts increase both in severity and frequency globally, the effects take place at a local scale.

The effects of climate change also affect the Netherlands, historically seen as a water abundant country. However, 2022 was a year of records in the Netherlands, it was the driest year of the century (Royal Dutch Meteorological Institute, 2022); in March, sunlight records were broken (Sittard-Geleen, 2022); and in mid-February, a triplet storm hit the Netherlands. Apart from the strong winds, water rose to dangerous levels and risks of flooding were apparent (Rijkswaterstaat, 2022). These records were broken only two years after a multi-year drought affected north-western Europe from 2018 till 2020, which intensity was unprecedented (Rackovec et al., 2022). Currently, these events are rare, yet, likely to become less extraordinary in the coming decades. It is predicted that the Netherlands will become hotter, dryer, and wetter (Climate Adaptation Services foundation, 2016). Besides, models indicate that multi-year droughts are going to increase both in frequency and severity in Europe (Van der Wiel et al., 2022; Rackovec et al., 2022). The people living in the Netherlands have always regarded themselves to be living in a water-rich area. As a result, the concept of drought has gained little attention. However, the availability of water has become less self-evident and will likely further decline in the future. It therefore is necessary to build resilience against droughts.

Agriculture depends on water as a natural resource and is therefore highly affected by droughts. Droughts can cause production and income losses for farmers, as well as food shortages in the Netherlands and abroad. At the same time, farmers play a key role in water management as agriculture makes up 60% of the land use in the Netherlands (Kranenberg, 2021). Already, improving drought resilience is on the national governments agenda. Currently, it is installing incentives for farmers to become more drought resilient by making investments into more sustainable water management practices [SWMP] and land use. These incentives, in the form of subsidies, are funded together by the national government, the provinces, and the local water authorities. The LTO is authorised for the distribution these subsidies. However, Widespread application to these subsidies resulting in sector wide drought adaptation requires more than the presence of incentives. It also requires knowing how the key stakeholders, i.e., farmers, make their decisions and what their objectives in obtaining drought resilience are. Therefore, this thesis focusses on the decision to implement SWMP by farmers in the region of Salland, a region with local differences in drought sensitivity and water abundancy.

In the academic literature, dispersed farmer decision models based on either economical or psychological factors exist. Only few models combine these factors. For instance, Grothmann and Patt (2005) developed the Model of Proactive Adaptation to Climate Change to show the interrelation of individual cognition, economic, and social factors in explaining climate adaptation efforts. However, in this model economical and psychological factors are imbalanced. Authors in both strands name drought experience as one of the influencing factors in decision making, yet just how this experience affect decision making and the implementation of SWMP by farmers remains poorly understood.

## 1.2 Research problem and objective

*Research Problem*

The Netherlands is facing an increase in both the frequency and the intensity of droughts. The sector most affected by this increase is the agricultural sector, as they manage 60% of the land, and are historically reliant on rainwater. To achieve the sustainable development goals of the UN and to better manage drought, more SWMP must be implemented (UN, 2020).

Two main strand exist in the literature on farmers' decision-making. The first focusses on technical and physical variables from a neoliberal economics perspective. One example of this is the Pressure State Response Model. The latter strand focusses on the individual differences in farmers, often related to psychological factors. These studies are often based on the Protection Motivation Theory. In both strands, institutional and social settings are deemed important. According to Hanger-Kopp and Palka (2021), most studies investigate farmers' decision-making among smallholder farmers in low-income countries without a highly regulated institutional structure. Few studies have been conducted in countries with a highly regulated institutional structure and a well-established economic viable agricultural sector. These two key features can lead to differences in farmers' decision-making. These two features can lead to other farmers' decision-making factors than those well-researched in the literature. Therefore, it is worthwhile to study farmers' decision-making in a highly regulated country, with a viable agricultural sector, like the Netherlands.

Experience with a climate disaster, such as drought, is an indicator of adaptation decisions. The evidence on how experience influences this decision is contradictory. Rey et al. (2017) and Keshavarz and Karami (2013) found that experience with multiple droughts affect the type of drought management practices used by farmers. This differs from the finding of Habita et al. (2012), who found that reoccurring droughts can demotivate farmers' enthusiasm for production inputs. Exactly how drought experience contributes to this decision remains poorly understood.

*Research objective*

This thesis aims to reveal the effect of drought experience on the implementation of SWMP by farmers. For this purpose, state-of-the-art farmer decision models were reviewed. The factors identified with this review were used to develop a framework for mid-sized farmer enterprises that harvest their own feed. This framework is tailored to include decisions on drought management as a long-term impact and risk, with a focus on the contribution of experience in the final implementation of SWMP. This framework was tested with dairy farmers in the Salland region in the Netherlands, a region with differences in water distribution, where farmers have different experiences with drought during the past few drought seasons. This empirical research assesses and refines the developed framework on implementing SWMP amongst dairy farmers.

## 1.3 Research question

In order to achieve the research objectives, the following main research question is formulated:

- *How does experience with drought influence the implementation of sustainable water management into agricultural practices among dairy farmers in Salland?*

The main research question is answered based on the answers to three sub-questions. To answer the main research question, the theoretical framework explores the factors that influence the farmers' decision-making processes identified in previous studies. Thereafter, the factors were used as a basis for the sub-questions and further research. As the institutional setting was one of the factors identified in the theoretical framework, the first sub-question explores the water management setting in Salland:

1. *What actors and policies are included in the water governance and management context in Salland in relation to drought in the agricultural sector?*

The second sub-question explores how experience alters the decision-making process by investigating the relation between experience and the different farmers' decision-making factors:

2. *How does experience with drought affect the farmers' decision-making process in implementing sustainable water management practices?*

The final sub-question addresses the relationship between drought experience and the implementation of SWMP. It does so by connecting the type and degree of experience with drought to the actual implementation of SWMP by farmers:

3. *How does experience with drought affect the degree of implementation of sustainable water management practices by farmers?*

**1.4 Societal and scientific relevance**

The outcomes of this research are relevant both for the society and the scientific community. The results can aid better implementation of drought management policies by farmers by considering how different degrees of experience affect farmers' implementation of SWMP. When the drought resilience of farmers increases, the risk of agricultural production loss decreases, and in turn, society will be better prepared for the changing climate. Droughts can have major indirect impact on society through decreased agricultural output resulting in food shortages. Due to climate change, the Netherlands is expected to endure severe droughts more frequently, as signalled by the recent droughts. In 2018, a severe drought hit the Netherlands, and its estimated economic damage to the agricultural, water and shipping sectors lies between 450 and 2080 million euros (Van Oldenborg et al., 2020). In 2022, the Southern Agricultural and Horticultural Organisation [ZLTO] warned for food shortages due to drought in the early spring (Dutch Broadcasting Foundation [NOS], 2022b). According to the ZLTO, due to the irrigation bans from the regional water authority Brabantse Delta, farmers in the south of the Netherlands may not irrigate their crops well enough to let them grow. This shows the disastrous impact drought can have on society and farmers, as well as the need for improved drought resilience.

This research attempts to contribute to the scientific literature by gaining a deeper understanding of how experience contributes to the choice of implementing SWMP. In the academic literature concerned with farmers' decision-making, there are two main strands. The first strand focusses on economic decisions based on objective variables like farm characteristics, capital for investment and market command. These studies are often based upon the Pressure State Release Model [PSRM]. The second strand of research focusses on the individual differences in farmers, often related to psychological factors. These studies are mostly based upon the Protection Motivation Theory. According to Hanger-Kopp and Palka (2021), most of the studies investigate farmers' decision-making among farmers in developing countries with low income levels and without a well-developed institutional structure. To date, few studies have been conducted in developed countries with a well-developed institutional structure and among higher income farming enterprises (Hanger-Kopp and Palka, 2021). These two features can lead to other influential farmers' decision-making factors than those that are well-researched in the literature and therefore, it is useful to study farmers' decision-making in a highly regulated, and high-income country like the Netherlands.

**1.5 Thesis outline**

Chapter 2 presents the theoretical framework of the thesis, reviewing the literature on climate adaptation and farmer decision making, and ending with the developed theoretical framework. Chapter 3 displays the methodology used to answer the research questions. Chapter 4 shows the research results per sub-question. Chapter 5 discusses the implications of these results. Here, the results are linked to the factors identified in Chapter 2 and discussed in relation to previous studies. Chapter 6 presents the conclusions of the research and recommendations for future research.

# 2. Theoretical framework

This chapter describes the theoretical framework of the thesis. It does so by presenting the literature review in multiple directions. First the concepts of climate change, droughts, and possible sustainable solutions for agricultural water management are explored. Thereafter, established explanations for farmers' decision-making are presented, with a specific focus on drought. This starts with investigating more economic-oriented approaches, then psychological approaches are explored, which is followed by an investigation of the influence of the societal and institutional contexts. After that, it introduces the concept of drought experience as a possible enhancing factor to attributes identified in the first part of the literature review, and as an attributor to the actual implementation of more SWMP by farmers. This chapter concludes by combining these three parts into a coherent framework.

## 2.1 Climate change and risk mitigation

This section explores climate change and its influence on the frequency and severity of droughts. The concepts of, and the differences between drought and water scarcity are explained, and the risk drought poses for the agricultural sector is defined. This section finishes with examining the measures farmers can take to mitigate the risk drought poses.

### *2.1.1 Drought and water scarcity*

There are multiple definitions for drought. The first stems from aridity, where drought is a permanent characteristic of a dry area with low rainfall (Pereira et al., 2002). In this thesis however, drought is not treated as a characteristic of a region, but as a deviation from the normal situation. These type of droughts can occur in regions with high, and with low rainfall. Normally, droughts occur when a prolonged time period experiences a natural reduction of rainfall (Whilite, 2000). They are slow-onset events which can last from several weeks to years. According to the U.N. Office for Disaster Risk Reduction [UNODRR] (2021), the most important characteristics of a drought are "frequency, severity or magnitude, intensity and duration", onset, peak month and area affected can significantly affect the impact of the drought (pp. 29). These characteristics help define droughts into four categories. Most authors distinguish three types of drought: meteorological, soil moisture or agricultural, and hydrological droughts (UNODRR, 2021). However, according to the UNODRR (2021), these types can be seen as subsequent stages of drought following the hydrological cycle. Recently, also the concepts of mega and flash droughts have been gaining importance. For this thesis, two of these 'types' of drought are of importance, namely, the agricultural or soil moisture drought, and flash droughts.

Agricultural droughts often follow after meteorological droughts, in which there is a sustained period with reduced or no rainfall, or after hydrological droughts, when river flows are below the average (Whilite, 2000). For agricultural droughts, there is made a link between the results of meteorological droughts and agricultural needs. A drought becomes an Agricultural drought when the soil moisture levels are depleted to the amount where crops are affected (Whilite, 2000). Because crops demand different water levels at different levels of growth, the timing of a drought can largely affect the impact of the drought. Flash droughts can also cause agricultural droughts, flash droughts have a shorter time span before the water deficits are notable. Usually there is a period shorter that three months of high temperatures which can be combined with strong winds, this results in fast depletion of soil moisture and increased evaporation, flash droughts can have major impacts with regard to the agricultural sector (Mo and Lettenmaier, 2016).

In this thesis, water scarcity is treated as the result of a period of drought, and means that the water demand is higher than the water available. This happens in the agricultural drought, when soil moisture levels are insufficient for sustaining crops. It is water scarcity in the growth season that poses the risk to farmers. When water scarcity occurs, farmers must reduce their water usage, which can result in output losses later in the agricultural season.

### *2.1.2 Climate change and drought risk*

Drought and water scarcity are becoming more prominent in Northwest Europe due to climate change. A region historically characterised by water abundancy and as a result, with little attention to stresses and strains resulting from drought. Besides this historical unawareness, drought is less visible and slower than flooding, occurring underground and causing delayed impacts that can extend to months or years after the start of the drought (UNODRR, 2021). Farmers are directly affected by drought, as it can result in agricultural capacity loss. When droughts reoccur, they can demotivate farmers' enthusiasm for production inputs (Habita et al., 2012). However, there are more indirect and cascading impacts of droughts; it can reduce groundwater level, impact nature areas, and result in increased competition between water usages (Bressers, 2016). Water shortages can impact public health, the economy, and the environment.

Aside from becoming dryer, the Netherlands is also predicted to become hotter and wetter because of climate change. However, as UNODRR (2021) notices: "more water on average does not mean more water when it is needed" (pp.30). The combination of periods of drought, as well as periods of water surplus, increases the need for sustainable water management approaches. Already there are many initiatives to combine solutions for high water levels with those mitigating the effects of droughts. Farmers found a solution in water wells. The NOS (2019) reported that many farmers switched to groundwater wells over surface and rainwater use due to three sequential summers (2018, 2019, and 2020) facing droughts. This solution, however, is noted to have severe effects on soil quality and nature (Pointer, 2021), as the use of groundwater wells lowers the water level even further. When droughts occur in regions where groundwater resources are depleted, there is a significant risk to water and food security (UNODRR, 2021). Other solutions focus on storing rainwater underground. An example of this is the 'crystal spring' in the city of Apeldoorn, which can capture up to 200.000 litres of pluvial water and can store it for dryer times (Apeldoorn Municipality, 2019). Some farmers adopt similar approaches. The increase in the frequency of drought periods requires farmers to find other, more sustainable solutions for their farm-level water management.

Stratelligence (2021), investigated the economic risk freshwater shortages pose for the Netherlands as part of the Deltaplan Agricultural Water management [DAW]. They estimate that currently, the agricultural sector risks 305 million euros in a 'regular year'. Economic risk reaches 450 million euros in a 'regular year' when Stratelligence investigated the extreme (climate change) scenario by 2050. This rapport only looked at 'regular years', an earlier rapport by the Ministry of Economic Affairs, Agriculture and Innovation (2011), estimated that in 'extreme dry years', the agricultural sector may face economic losses up to 1800 million euros. Due to climate change and socioeconomic developments, this loss might fivefold in 2050. This would mean that the agricultural sector will face a loss of 700 million euros every two years by 2050.

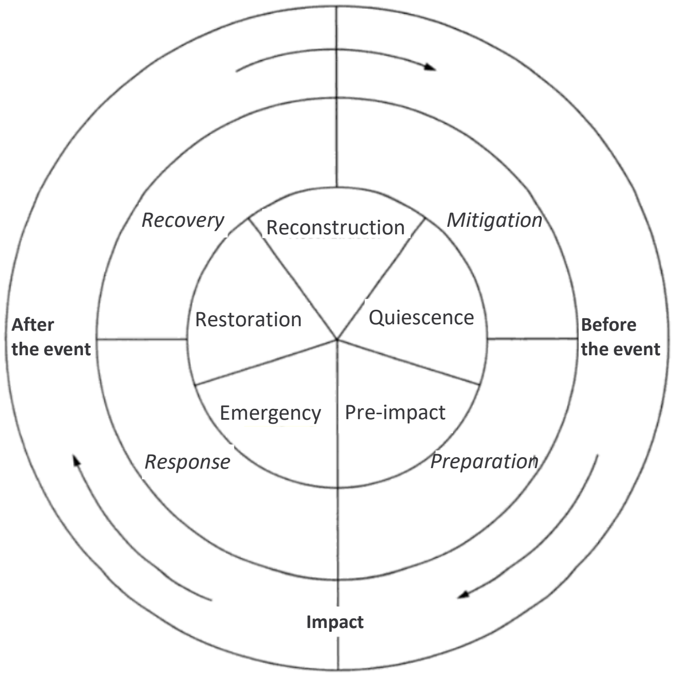
Drought occurrence is a feature natural to the climate and is not a problem in itself. Among scholars, there is a growing consensus that the risk a natural event poses is the result of both a natural and a social component (Whilite, 2000). In the risk formula, this is noted as follows: Risk = Hazard x Exposure x Vulnerability (UNODRR, 2021). Although the hazard (e.g., the drought) itself cannot be altered, vulnerability, which relates to the susceptibility to impacts, lack of coping capacity, and the ability to adapt to changing conditions, to the hazard can be reduced. By decreasing vulnerability, the ability to withstand, or adapt to a hazard is increased.

### *2.1.3 Sustainability and resilience in agricultural practices*

In this thesis, resilience is treated as a component contributing to the sustainability of a system. The argument follows the reasoning of Leichenko (2011), namely that a resilience enhancing measure can contribute to the sustainability of a system, but that increasing sustainability does not necessarily enhance resilience. Resilience-enhancing measures can thus aid the sustainability of the agricultural practises.

Meerow et al. (2016), name four mechanisms of resilience to cope with a disturbance: absorbing the disturbance while maintaining the systems original state, adapting to, or transforming to the disturbance, or by vastly reverting back to the systems original state after the disturbance (Meerow et al., 2016). To increase resilience, one can take measures aimed at reducing vulnerability to the disturbance. According to the risk formula in section 2.1.2, impact happens when the natural phenomenon meets the exposure and vulnerability of the farmer. The main natural phenomenon affecting farmers during agricultural droughts is a soil moisture deficit. The impact of this phenomenon can be enlarged by the farmers’ vulnerability, which is highest in times when irrigation is needed in the growing season of crops. The combination of these two factors can cause crop yield reduction or losses and result in less agricultural profit.

Figure 2.1 - Disaster-risk management cycle




*Source:* Alexander (2002:6)

Measures to increase drought resilience can be taken in all stages of the disaster-risk management [DRM] cycle (Alexander, 2002), and should aim to reduce vulnerability to soil moisture deficits. This cycle is shown in Figure 2.1. The DRM-cycle has four stages, the prevention, the preparation, the response, and the recover stage. Measures taken can lower the vulnerability to a risk.

### *2.1.4 Sustainable water management practices to improve drought resilience*

For sustainable use of groundwater, the definition proposed by Metz and Glaus (2019) is adopted, sustainable use of a natural resource is the use without endangering the reproductive capacity of the resource. The groundwater wells currently in use (see 2.1.2) deplete the underground water storages even further and bring harm to other natural resources (European Environmental Agency, 2021). Therefore, other, more sustainable practices should be adopted.

Possible SWMP for farmers can be categorised by the degree of resilience added. This has to do with the diversity and redundancy aspects of resilience (Meerow et al., 2016). If a farmer only implements one SWMP in one stage of the DRM-cycle, there still is a high chance that that one measure will fail under severe droughts. Resilience can be enhanced by installing multiple, and diverse

SWMP. The overall resilience against droughts will be higher because the likelihood that one or more measure still functions during droughts is increased.

Another dimension of SWMP implementation is whether the practices implemented are short-term, semi-structural, or structural adaptations. Short-term measures indicate no finite change in the farming structure and operations, and merely focus on coping with the drought at hand. Examples of short-term measures are: avoiding a second crop, purchasing extra water, and the reduction of water usage at times of drought (Keshavarz and Karami, 2013; Rey et al.,2017). Opposed to short-term measures, semi-structural measures need to be taken before the drought hits, but need to be re-established each season. Examples of these measures are drought resilient crop choices or water retention in ditches (Van Duinen et al., 2014; Keshavarz and Karami, 2013). Structural measures then focus on the preparation to future droughts. Examples of long-term adaptation decisions are: constructing reservoirs, soil management, and the inclusion of drought into the business plan to develop a drought-resilient company (Keshavarz and Karami, 2013; Rey et al.,2017). Thus, to better prepare for future droughts, (semi-)structural adaptations should be sought after.

From these two dimensions of SWMP, a typology is constructed about the resilience the combination of SWMPs adds to the farming enterprise. This typology is shown in Table 2.1. In this typology, multiple measures covers both a redundancy in measures, and a diversity in type of measures.

Table 2.1 - Typology of SWMP

<table>
<tr><th></th><th>Structural measures</th><th>Semi-structural measures</th><th>Short term measures</th></tr>
<tr><td>3+ measures</td><td colspan="3">Highly drought resilience enhancing SWMP<br>When at least 1 is structural</td></tr>
<tr><td>2+ measures</td><td></td><td colspan="2">Mildly drought resilience enhancing SWMP<br>When at least 1 is semi-structural</td></tr>
<tr><td>Singular measures</td><td colspan="2">Weakly drought resilience enhancing SWMP</td><td>No drought resilience enhancing SWMP</td></tr>
</table>

Singular measures, even structural ones, are deemed to be less resilient than diverse measures, even when they are semi-structural and combined with short-term. Because of the low diversity and redundancy the system is more prone to failure when one measure cannot handle the drought. Short-term measures, when they are diverse, can be hard to manage during acute stresses and will likely be implemented in a disorderly and costly manner. How farmers are assigned to of the four categories is further explained in section 3.5 Data analysis.

Table 2.2 gives an overview of the SWMP categories that farmers can employ. The full list of measures and practices is included in Appendix A, indicating whether these practices are structural, semi-structural or short-term, and where in the DRM cycle the measure is staged. There are no measures mentioned in the recovery stage, examples of such measures would be insurance and price increasement, however, these measures do not contribute to the sustainability and therefore are excluded from this thesis.

For the practices and technologies in Table 2.2, several barriers exist to their implementation. According to the Organisation for Economic Co-operation and Development [OECD] (2010), one of such barriers is the knowledge and information deficiencies among farmers The recommendations offered to increase this knowledge focusses mainly on creating information-sharing platforms, and thus do not consider how different experiences among the target group can play a key role in their implementation processes.

Table 2.2 - Categories of sustainable water management practices

| Measure category | Duration | DRM stage | References |
|---|---|---|---|
| Targeted irrigation systems | Mostly structural (e.g., installing drip-irrigation), short term when selective irrigation. | Prevention and response | Hanger-Kopp and Palka, 2021; Holman et al., 2021; Keshavarz and Karami, 2013; Dutch Agricultural and Horticultural Organisation [LTO], 2013; OECD, 2010; Rey et al., 2017; Van Duinen et al., 2014. |
| Rainwater storage | Semi-structural | Preparation | Habiba et al., 2012; Hanger-Kopp and Palka, 2021; Keshavarz and Karami, 2013; LTO, 2013; OECD, 2010; Van Duinen et al., 2014. |
| Diverse water sources | Mostly structural measures. | Most in prevention, some in response. | Habiba et al., 2012; Keshavarz and Karami, 2013; LTO, 2013; OECD, 2010; Rey et al., 2017; Van Duinen et al., 2014. |
| Soil moisture management | Structural | Prevention | Habiba et al., 2012; Hanger-Kopp and Palka, 2021; Holman et al., 2021; Knutson et al., 2011; LTO, 2013; OECD, 2010. |
| Crop choices | Mostly semi-structural. Short term (e.g., avoidance of second crop yield). | Prevention (when long term) Response (when short term) | Habiba et al., 2012; Hanger-Kopp and Palka, 2021; Holman et al., 2021; Keshavarz and Karami, 2013; Knutson et al., 2011; OECD, 2010; Rey et al., 2017; Van Duinen et al., 2014. |
| Seasonal water storage (surplus) | Structural | Preparation | LTO, 2013; OECD, 2010; Van Duinen et al., 2014. |
| Water retainment | Semi-structural | Preparation and prevention. | LTO, 2013; Van Duinen et al., 2014. |
| Changes in farm management | Structural | Prevention | Habiba et al., 2012; Holman et al., 2021; Rey et al., 2017. |

## 2.2 Farmers' decision-making

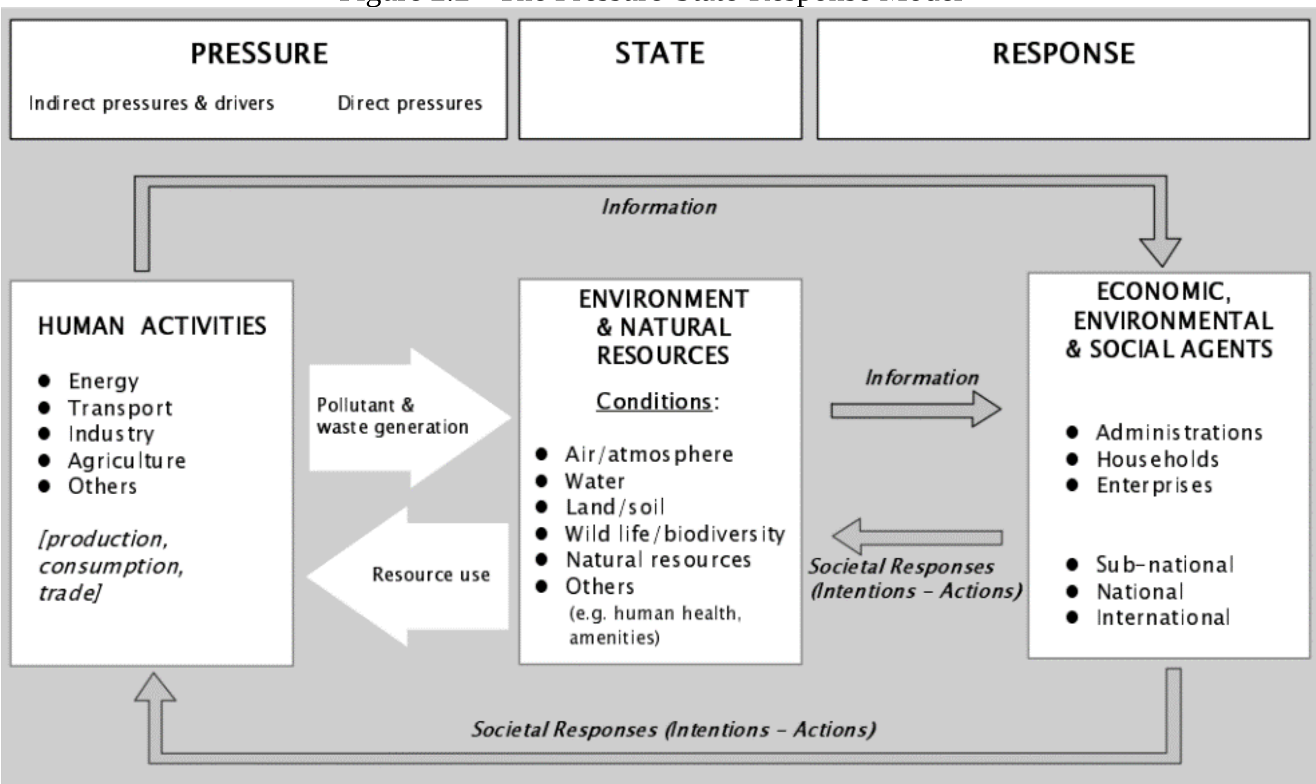
There are two main strands in the scientific literature on farmers' decision-making. The first strand focusses on economic decisions based on variables external to the farmer, like farm characteristics, capital for investment and market command. These studies are often based upon the Pressure-State-Response-Model [PSRM]. The second strand focusses on the individual differences internal to the farmers, frequently related to psychological factors. These studies are often based on the Protection Motivation Theory. According to Hanger-Kopp and Palka (2021), most of the studies investigate farmers' decision-making among smallholder farmers in developing countries with low income and without a well-developed institutional structure. To date, few studies have been conducted in developed countries with a well-developed institutional structure and among larger farming enterprises. (Hanger-Kopp and Palka, 2021). These two features can lead to other influential farmers' decision-making factors than those well-researched in the literature. Therefore, it is useful to study farmers' decision-making in a highly regulated country with a viable agricultural sector like the Netherlands.

### *2.2.1 Neo-liberal economics perspective to farmer decision-making*

Many studies employ constrained optimization models to study farmers' adaptive decision-making in the context of water scarcity. These studies often take a neoliberal economics perspective, assuming full rationality and homogeneity of farmers (Van Duinen et al., 2014). These studies generally also have two other assumptions: agents do not interact with each other, and there is a focus on market equilibrium (Tesfatsion and Judd, 2006). These studies take an instrumental approach and focus on technical and physical factors to explain decision-making processes. These factors can be said to interfere with farmer decisions at a farm level, impacted by the location and direct environment of the farm.

Many of these studies use the PSRM developed by the OECD (2013), which focusses on the needs of a sector as pressure, the conditions of the sector as state, and actions to achieve the needs of the sector as response (Figure 2.2). In agricultural adaptation, the pressure is the need to adapt agricultural practices to climate change; the state is the farmers' need to sustain their families and enterprises, while also adapting to market demands and climate change to keep their enterprise sustainable; and the response would be the decision to implement sustainable practices (Röling, 2003).

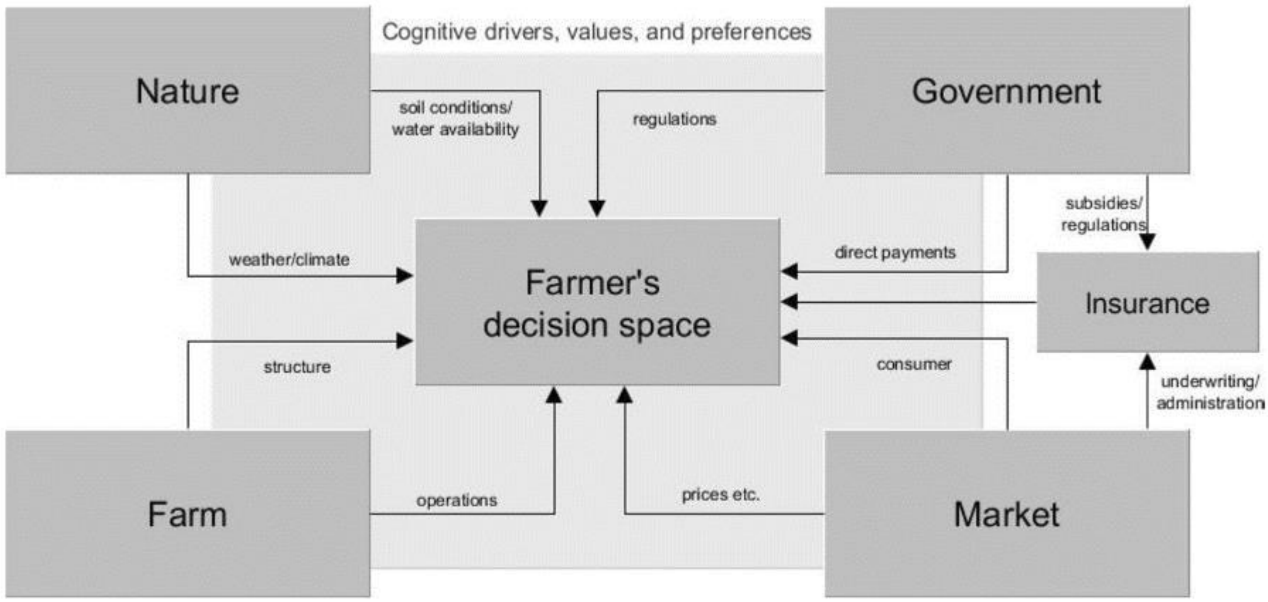
Figure 2.2 - The Pressure-State-Response Model




*Source:* OECD (2003)

Variations of this model include impacts and driving forces (Holman et al., 2020; Gisladottir and Stocking, 2005; Gupta et al., 2019). In these variations, climate change is seen as a driving force, impacts are generated through current states and impact the final response decisions. Hanger-Kopp and Palka (2021) elaborate the economics approach by including institutional factors. They assume that in developed countries, the institutional structure in place may be more important in their decision than personal beliefs or economic incentives. Their model is shown in Figure 2.3.

Figure 2.3 - Farmer's Decision Space




*Source:* Hanger-Kopp and Palka (2021)

Figure 2.3 illustrates the restricted area in which farmers make their decisions and the range of options they are allowed to choose from. Hanger-Kopp and Palka (2021) call this 'farmer's decision space'. Here, four spheres pose restrictions on the choices possible, namely nature, government, market, and farm. The farmer decision space lies within those restrictions. The factors found influential in farmers' decision-making by Liu et al., (2019) largely align with those of Hanger-Kopp and Palka (2021). Liu et al. (2019) found physical factors, economic factors, personal views of the farmer, crop profiles, availability of resources, and government policy to be influential.

The most commonly used technological and physical factors are summarised in Table 2.3. These factors are external, or externally imposed upon the farmer. Demographics are not included, as it was not often covered by scholars. When certain demographic factors (e.g., age and education) are covered, they were linked to other factors. For instance, age would change the experience with droughts, and was linked to higher levels of belief in climate change (Habiba et al., 2012; Knutson et al., 2011; Liu et al., 2019). Education was linked to innovative characters, and more knowledge on available subsidies, technical solutions, and legislation (Habiba et al., 2012). Therefore, demographics are deemed to be intermediate variables, the result of which can be found in the other factors.

Table 2.3 – Farm level factors that affect farmers' decision-making

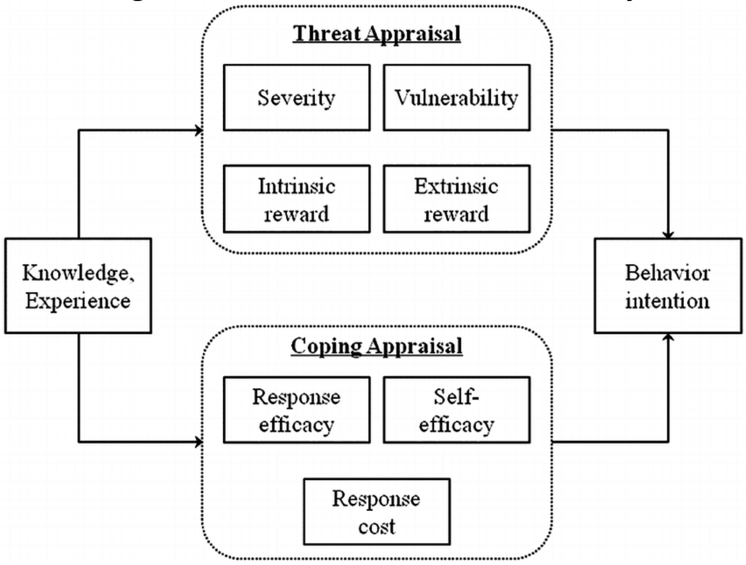
| Factors | Description | References |
|---|---|---|
| **External adaptive capacity** | The ability to make the adaptations when wanted. (e.g., capital for investment and to handle market disadvantages and profits forgone; power; knowledge of policies, legislation, and solutions). | Bagagnan et al., 2019; Ghanian et al., 2020; Grothmann and Patt, 2005; Guo et al., 2022; Holman et al., 2021; Keshavarz and Karami, 2013; 2016; Knutson et al., 2011; Liu et al., 2019; Özerol and Bressers, 2017; Röling, 2003; Shiferaw et al., 2009. |
| **Experience** | Former experience with droughts. This includes the following dimensions: historical experience, personal impact, recent impact, and frequent exposure. | Bagagnan et al., 2019; Ghanian et al., 2020; Grothmann and Patt, 2005; Habiba et al., 2012; Keshavarz and Karami, 2013; Keshvaraz et al., 2013; Rey et al., 2017; Sharma and Patt, 2011; Weber, 2006. |

| | | |
|---|---|---|
| **Agroecosystem** | Characteristics of the farm (e.g., farm structure, size and operations), as well as the ecosystem the farm operates in and is shaped by. The farm is dependent on the soil condition, water availability and the weather/climate at its location. | Guo et al., 2022; Hanger-Kopp and Palka, 2021; Holman et al., 2021; Keshavaraz et al., 2010; Khanian et al., 2017; Liu et al., 2019; Özerol and Bressers, 2017; Shiferaw et al., 2009. |
| **Market** | Market prices and command. | Hanger-Kopp and Palka, 2021; Holman et al., 2021; Knutson et al., 2011; Shiferaw et al., 2009. |

### *2.2.2 Psychological perspective to farmer decision-making*

Aside from economic approaches, there is an upcoming stream of studies focusing on psychological models. These studies argue that decision models from the neoliberal economics perspective fail to account for the complexity farmers face when making decisions. Often posed arguments are that farmers do not possess full rationality, that they do not know the complete set of options available and their impacts, the changing climate creates uncertainty, and finally that farmers are not a homogeneous population (Van Duinen et al., 2014; Röling, 2003; Knutson et al., 2011; Weber, 2006). According to these studies, it makes sense to include factors shaping farmers' behavior intention in their decision models. These factors can be said to interfere with farmer decisions at he individual farmer level, impacted by their own life-experiences and beliefs. Most studies using psychological models for farmers decision-making apply the Protection Motivation Theory. A visualisation of this theory is shown in an .

Figure 2.4 - Protective Motivation Theory

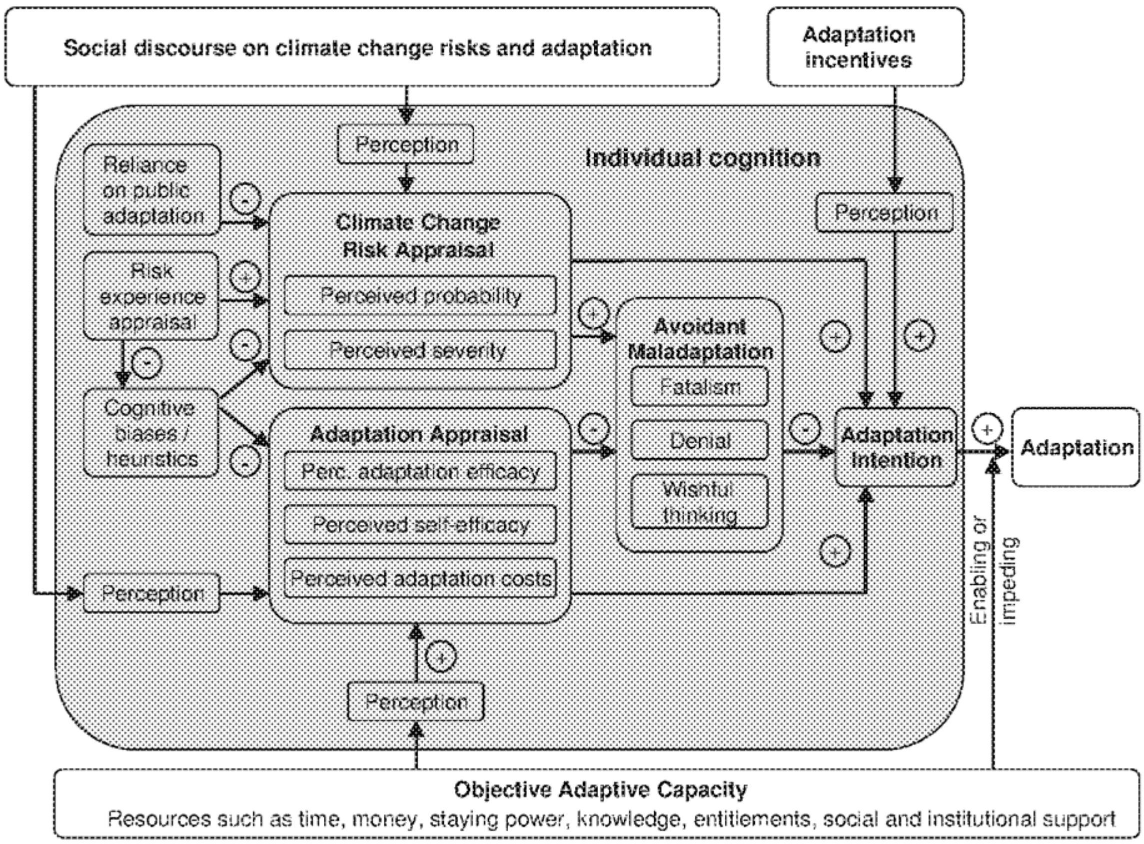



*Source*: Bagagnan et al. (2019)

The underlying theory of Protection Motivation Theory is based on findings in the (neuro-)psychological domain that "*emotions and feelings have been connected, by learning (e.g., former outcomes of decisions), to predicted future outcomes of certain scenarios*" (Damasio, 1994, pp. 174). In uncertain situations, where information is incomplete "affective feelings would increase the accuracy and efficiency of the decision process" (Peters and Slovic, 2000, pp. 1466). Protection Motivation Theory reduction behaviour based upon the perception of actors. It assumes that threat- and coping-appraisals are formed from previous experience and knowledge (Keshavarz and Karami, 2016). Different values for these two forms of appraisal then result in intended action to protect oneself or one's property. Threat-appraisal is the individuals' assessment of the risk that they face. This threat is defined as perceived vulnerability to, and the severity of a disturbance. Coping-appraisal is closely related to response efficacy, self-efficacy, and response cost, it refers to an individuals' perceived ability to respond to a threat in a manner that the risk is sufficiently reduced (Keshavarz and Karami, 2016). Based on the outcomes of these two variables, a person responds to a threat.

Two types of responses are often named in the literature concerning Protection Motivation Theory, namely 'adaptation' and 'maladaptation'. Adaptive responses result in risk reduction, whereas maladaptation actions fail to do so (Grothmann and Patt, 2005). Maladaptation often occurs due to two reasons, either because the actor shows avoidant behaviour, or because of unintended wrong adaptations. According to Grothmann and Patt (2005), avoidant maladaptation occurs if an actor has low perceived adaptive capacity, even if his risk perception is high. This maladaptation or effective adaptation can be explained and predicted by the Model of Proactive Adaptation to Climate Change [MPACC]. In the MPACC, Grothmann and Patt (2005) extended the Protection Motivation Theory to include objective adaptive capacity, which is closely related to resources available; social discourse; and adaptation incentives. From Protection Motivation Theory they included threat and coping-appraisal (which they term risk appraisal and adaptation appraisal respectively). The MPACC model is visualised in Figure 2.5.

Figure 2.5 – Model of Proactive Adaptation to Climate Change




*Source:* Grothmann and Patt (2005)

When the object of research is the individual farmer, some studies focus on what farmers have, know, and want (Özerol and Bressers, 2017; Röling, 2003). What farmers have is related to the economic approaches. Here the resources of a farmer are used as an indicator for decision-making, as resources are related to what they can or cannot do. Knowing is related to the perspectives farmers have of both the problem, and their possibilities to change this problem. What farmers want, or their motivation, according to Bressers et al. (2016), is based upon three variables: 'internal values and goals', 'external pressure', and 'self-efficacy assessment'.

Rölling (2003) relates using incentives and instruments, as well as learning strategies to what farmers want, gets, and knows, along with effectiveness and policy focus, and created a matrix with adaptation strategies for each characteristic of the farmer. Özerol and Bressers (2017) connect the same variables to changes in the systems external to the farmer, namely the agroecosystem and the governance system. They investigate how changes in these systems affect either what farmers have, see, or know to make changes in their decisions. From the literature review above, identified several psychological indicators that can explain farmers' decision-making are identified. These psychological indicators are grouped in different overarching categories. These factors are internal to the farmer. These categories are shown in Table 2.4, as well as a summary of the factors the category is based upon.

Table 2.4 – Farmer level factors that affect farmers' decision-making

| Factors | Description | References |
|---|---|---|
| **Internal adaptive capacity [IAC]** | The perceived capability by the farmer to effectively solve the problem himself. This includes self-efficacy belief, adaptation intention, former (mal)adaptation, perceived adaptation success, and feeling of ownership of the problem. The willingness to continue the farm and to try innovative methods under uncertainty are related to IAC. | Bagagnan et al., 2019;Bressers et al., 2016; Ghanian et al., 2020; Grothmann and Patt, 2005; Holman et al., 2021; Keshavarz and Karami, 2013; 2016; Knutson et al., 2011; Liu et al., 2019; Özerol and Bressers, 2017; Pearson and Dare, 2021; Röling, 2003; Van den berg et al., 2000. |
| **Belief in climate change** | The belief or disbelief in climate change and that this will result in risks to the farm that need be mitigated through adaptation. | Bagagnan et al., 2019; Ghanian et al., 2020; Grothmann and Patt, 2005; Habiba et al., 2012; Özerol and Bressers, 2017. |
| **Risk perception** | The perceived level of risk by the farmer. This includes perceived vulnerability, perceived severity, risk awareness, affective emotions felt, and feeling of alarm. | Bagagnan et al., 2019; Ghanian et al., 2020; Grothmann and Patt, 2005; Habiba et al., 2012; Keshavarz and Karami, 2016; Özerol and Bressers, 2017; Peters and Slovic, 2000; Rey et al., 2017; Röling, 2003; Sharma and Patt, 2011; Weber, 2006. |

### *2.2.3 Social and institutional Setting*

Although not a specific branch of studies, several social factors are included in both the economic and the psychological models. These factors interfere with farmer decisions at the societal level, impacted by the community they are part of and the broader institutional regime. The institutional setting can both hinder or support decision-making. Hinderance occurs through law and policy constraints. Some farmers find themselves constrained by the institutional setting to several adaptations that would economically or ecologically beneficial (Shiferaw et al., 2009). Vermunt et al. (2022), found that nature-inclusive agriculture is not rewarding enough for farmers in the Netherlands, since farmers are missing financial incentives. Furthermore, because they are not offered perspective, farmers hold off their investments in sustainable agricultural practices. Moreover, Vermunt et al. (2022) noted that the fragmentation in the Ministry of Agriculture hinders knowledge sharing and creates regime resistance. The institutional settings can be supportive through subsidies and knowledge-sharing. Hanger-Kopp and Palka (2021) found that farmers often consider the institutional structure and their compliance with it to receive subsidies for new investments. Similarly, Pearson and Dare (2021) state that farmers who better understood the institutional structure were also shown to implement more transformative measures than farmers who did not understand the institutional structure.

Another often named category is social factors. Grothmann and Patt (2005) elaborate on how the social discourse of climate change can alter individual risk perception when personal experience by that individual is low. Whereas social support can increase their Internal Adaptive Capacity [IAC]. Knutson et al. (2011) stated that peer pressure, as the influence of the social system is felt as a barrier among farmers. Related to this, is the influence of networks on farmers' decision-making. Van Duinen et al. (2012) state that in conditions of uncertainty, as with droughts induced by climate change, farmers interact and learn from each other. They share both information on risk perception, as on successful adaptation strategies. Individual farmers' decision-making is thus dependent on decisions of other farmers (Van Duinen et al., 2012). Pearson and Dare (2021) also stated that networking among farmers is one of the adaptation pathways to sustainability. The description of both categories are summarised in Table 2.5.

Table 2.5 – Societal level factors that affect farmers' decision-making

| Category | Description | References |
|---|---|---|
| **Institutional setting** | The institutional setting includes its structure, laws and policies in place. This can be enabling or hindering in the implementation of SWMP. | Grothmann and Patt, 2005; Hanger-Kopp and Palka, 2021; Holman et al., 2021; Keshavarz and Karami, 2016; Knutson et al., 2011; Liu et al., 2019; Özerol and Bressers, 2017; Pearson and Dare, 2021; Röling, 2003; Shiferaw et al., 2009; Vermunt et al., 2022. |
| **Social setting** | The social environment and discourse on climate adaptation. As well as the personal network and relations to others that implement SWMP or hold knowledge on drought (solutions). | Grothmann and Patt ,2005; Keshavarz and Karami, 2016; Knutson et al., 2011; Özerol and Bressers, 2017; Pearson and Dare, 2021; Shiferaw et al., 2009; Van Duinen et al., 2012. |

### 2.3 Defining drought experience

Two dimensions of disaster experience are frequently named: frequency and severity (Habiba et al., 2012; Rey et al., 2017; Sharma and Patt, 2011; Weber, 2006). The number of droughts farmers have endured can impact the way they cope with drought. Keshavarz and Karami (2013), state that the kind of measures implemented changes with the frequency farmers have endured water scarcity. These measures went from short-term solutions (e.g., avoiding a second crop or purchasing extra water), to long-term adaptations (e.g., constructing reservoirs and changing the cropping pattern). Rey et al. (2017), had similar findings. They noted that when farmers experienced more droughts, they went from the short-term solution of reduction of water usage at times of drought, to the inclusion of drought in their business plan to develop a drought resilient company.

Two indicators are relevant for the severity of drought. Sharma and Patt (2005) linked conflicting results in the effect of drought experience on affective responses to the different usages of severity. Main indicators of severity are the duration of the water shortage, as the buffering of a system gets drained over time (Wisner et al., 2004); and the loss of agricultural yield and profit, e.g., because of crop failure or restrictive water usage measures (Sharma and Patt, 2011; Bagagnan et al., 2019; Rey et al., 2017). It is assumed that the higher the severity of a disaster, the more comprehensive the measures taken. This means that there will be more than one measure in place and these measures will be diverse.

Another dimension towards experience with drought that closely relates to frequency is the time that has passed since the last period of drought. Many studies identify experience with natural disasters as one of the key predictors for increased disaster preparedness and response among citizens (Peters and Slovic, 2000; Sharma and Patt, 2011; Weber, 2006). According to several scholars, this is only the case with recent, personal experience and its impact on disaster preparedness fades over time (Chelleri et al., 2015; Sharma and Patt, 2011; Grothmann and Patt, 2005). Although these authors do not mention a time scale to distinguish between past and recent experiences, for the purpose of this thesis, past experiences are assumed to be more than 10 years ago.

A typology of drought experience is constructed from these three dimensions. This typology is shown in Table 2.6, along with a hypothesis for the implementation levels of SWMP, derived from Table 2.1. The columns show predicted levels of drought measures implemented by farmers with different levels of experience with drought.

Table 2.6 – Typology of Drought experience

| | | **High severity droughts** | **Low severity droughts** |
|---|---|---|---|
| **Recent personal experience** | **High frequency droughts** | Implementation of highly drought resilience enhancing SWMP | Implementation of weakly drought resilience enhancing SWMP |
| | **Low frequency droughts** | Implementation of mildly drought resilience enhancing SWMP | No implementation drought resilience enhancing SWMP and a reduced belief in the need to implement measures. |
| **Past personal experience** | **High frequency droughts** | Would have implemented highly drought resilience enhancing SWMP. However, due to climate change, these measures will not be able to cope with the increased severity of droughts. | Would have implemented weakly drought resilience enhancing SWMP However, due to climate change, this measure will not be able to cope with increased severity of droughts. |
| | **Low frequency droughts** | Former implementation of mildly drought resilience enhancing SWMP, but these are not in place anymore. | No implementation drought resilience enhancing SWMP and a reduced belief in the need to implement measures. |

In Table 2.6, the past personal experience row is greyed out. This is done so because the Netherlands recently experienced reoccurring droughts (2018, 2019, 2021, 2022), and therefore, farmers included in the study are likely to have recent personal experience. Earlier droughts were less significant and infrequent. For droughts in the same order of magnitude as the recent droughts, the most recent is 1976 (Royal Dutch Meteorological Institute, 2021). Therefore, the influence of past personal experience will not be investigated within this thesis.

### 2.4 Towards a framework of farmer decision-making under drought experience

The farmer decision models used by scholars and scientists their variables and indicators were grouped into different categories in Tables 2.3, 2.4, and 2.5. These categories form the basis of the Farmer Decision under Drought Experience Framework [FDDEF]. The full list of variables are presented in Appendix B. Based on the literature review, the factors affecting farm-level decisions are external adaptive capacity, experience, agroecosystem, and the market. These are complemented with three categories internally affecting the farmer's decision: IAC, belief in climate change, and risk perception. Finally, the societal and institutional were identified as societal wide factors influencing farmers' decision-making. In Figure 2.6, the impact of the different aspects of experience upon IAC and risk perception is graphically represented. Market and external adaptive capacity are combined in the FDDEF, as market command and prices can also limit feasible options available to the farmer.

The FDDEF shows that external adaptive capacity, the institutional context, and the agroecosystem impact the farmer decision space. Together these factors influence which options are available to the farmer. Within the decision space, there are three factors contributing to the final choice a farmer makes, namely belief in climate change, risk perception, and IAC. The combination of these factors results in the choice of the farmer between implementing and not implementing SWMP. If the choice of the farmer does not align with their decision space, maladaptation occurs.

Figure 2.6 – Farmer decision under drought experience framework

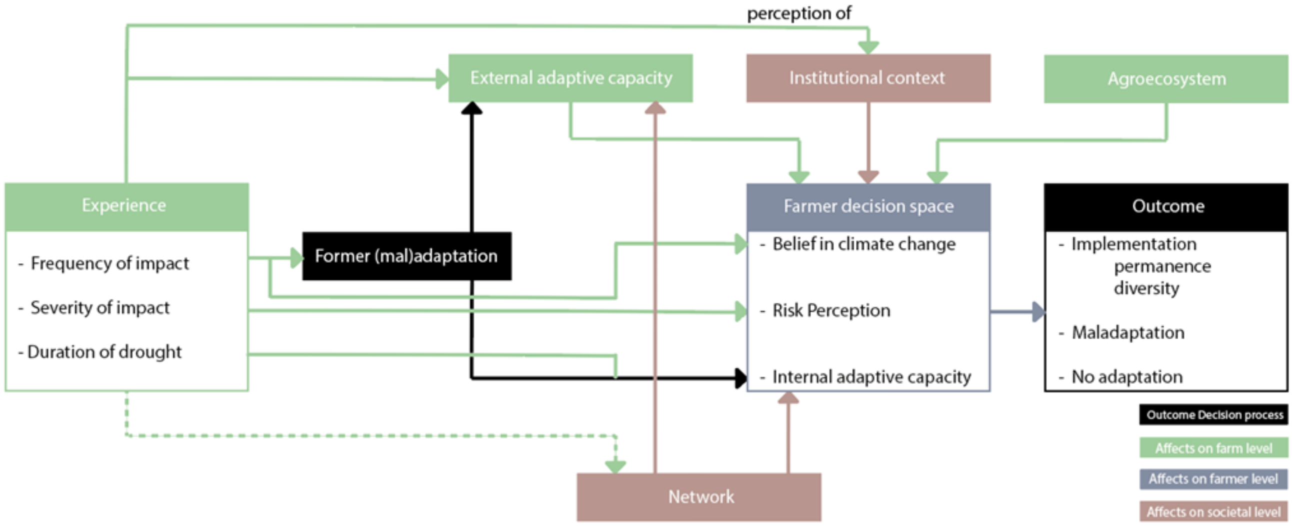



Figure 2.6 shows how the different dimensions of experience influence farmers' decision-making. Severity of previous events influences risk perception. If the past events were deemed severe and had a high direct impact on a farmer, this farmer probably has a greater risk perception than a farmer who experienced a drought but was not severely impacted by it. Frequency of impact influences IAC because if farmers experienced (severe) droughts, they will likely have implemented adaptations before. If these adaptations have worked as intended, the farmers' IAC is likely to be higher than when these measures failed to protect the farmer in a later drought period.

In the FDDEF, maladaptation was added as an intervening variable between frequency and IAC after the empirical study results indicated that this indeed is an important intervening factor. Other changes, originally not included after the literature review, were the impact of drought experience on external adaptive capacity and the perception of the institutional setting.

Experience also affects the social setting. For instance, a group of farmers with different experiences with drought, together are likely to have higher risk perception and IAC than individual farmers without drought experience. Through interaction within networks consisting of multiple farmers with different types of experience, IAC and risk perception can increase in farmers without experience as well. The societal discourse can moreover strive for more or less sustainable practices, which can result in farmers yielding to this 'pressure'. In Figure 2.6, this relationship is dashed, since the study did not yield trustworthy results to test it.

Based on the literature review, some assumptions can be made about the decision process. Farmers are more likely to implement SWMP when IAC is high. However, if the risk perception is low, the farmer will likely only implement a minimum of SWMP, mainly focussed on short term coping during new drought periods. With a higher number of droughts experienced, the type of measures implemented will have changed from short-term solutions to long-term adaptations. When the decision for SWMP does not co-align with the options available in the farmer decision space (restrictions can be posed by the external adaptive capacity, the agroecosystem, and the institutional setting), this will result in maladaptation or no adaptation.

There are also more direct ways in which drought experience contributes to SWMP implementation. Frequency of impact is related to the permanence of the SWMP implemented. When a farmer has experienced multiple droughts, SWMPs implemented will likely have changed from short term measures to more structural measures. Furthermore, the severity of the drought events endured is related to the diversity and redundancy of measures implemented. More severe drought events will likely result in more diversity among the SWMPs implemented by the farmer.

## 2.5 Concluding remarks on the theoretical framework

This chapter started with exploring the impact of increasing droughts on the agricultural sector, and possible SWMP that farmers can employ to reduce their vulnerability to droughts. Thereafter, a literature review was conducted on the most influential factors influencing the farmer decision process as identified by scholars. This review focussed on the two main approaches taken to study farmers' decision-making, namely the neoliberal economics, and the psychological approach, and complemented this by investigating the influence of social factors. From this review, overarching factors were constructed. From the neo-liberal approaches, the found indicators were summarised into the following factors: External adaptive capacity, Experience, Agroecosystem, and Market. The latter was combined with external adaptive capacity within the FDDEF. From the Psychological approach, the found indicators were summarised into the following factors: IAC, Belief in Climate change, and Risk perception. Lastly, institutional and social setting were identified to be influential in farmers' decision-making.

Thereafter, a literature review with a focus on drought and disaster experience was conducted. This review was used to conceptualise drought experience, and a typology with the different dimensions of drought experience was constructed. Then, the FDDEF was constructed to guide the empirical research in answering the second ("*How does experience with drought affect the farmers' decision-making process in implementing sustainable water management practices?*") and third ("*How does experience with drought affect the degree of implementation of Sustainable water management practices by farmers?*") sub-questions, as presented in chapter 4. The FDDEF presents the (hypothetical) relationship between drought experience and SWMP implementation, as well as presenting how the other factors influence either the decision space, or the decision process by farmers.

# 3. Methodology

This chapter presents the method used to test the theoretical framework and to answer the research questions. The first section discusses the design of the research. The second section shows the case and interviewees selection. Thereafter there is elaborated on what data will be collected and how it will be collected. This is followed by how the different variables are operationalised and with a plan for data analysis. This chapter ends with a discussion on ethical considerations.

## 3.1 Research design

This study is of a qualitative design, in which desk and field research are combined to answer the research questions. For sub-questions two and three, there are already implications made in the theory. Semi-structured interviews are conducted to elaborate and deepen the understanding of these questions. For sub-question two, document analysis is used as well as an expert interview. Aside of testing the framework with the interview responses, the deductive, explanatory character of the study can help better understand the relationship between drought experience and the implementation of SWMP as proposed in the theoretical framework.

*Strategy per sub-question*

1. *What actors and policies are included in the water governance and management context in Salland in relation to drought in the agricultural sector?*

To determine which actors and policies compromise the contextual situation of water management in Salland, I analysed several grey documents. These documents were collected through desk research. The focus is on documents of the Dutch government, the province of Overijssel, and the Drents Overijsselse Delta, the latter being the water authority involved in Salland. Interviews with farmers elaborate on their perception of these  policies, and their specific role in the governance context. These analyses clarify the governance structure in which the farmers operate. Furthermore, two expert interviews were conducted, one with a board member of the Drents Overijsselse Delta, and one with an employee of Province Overijssel concerned with Zoetwater voorziening Oost Nederland [ZON] (*Freshwater availability East Netherland*) - the main subsidy for drought adaptation for farmers.

2. *How does experience with drought affect the farmers' decision-making process in implementing sustainable water management practices?*

From the factors identified in the first sub-question, a conceptual framework was constructed in chapter 2.4. I tested the assumptions made to clarify how different factors affect farmer decision making through 12 semi-structured interviews with dairy farmers in Salland. After coding, these interviews allowed, , for comparison between degree of experience and differences in the levels of each of the decision-making factors identified.

3. *How does experience with drought affect the degree of implementation of Sustainable water management practices by farmers?*

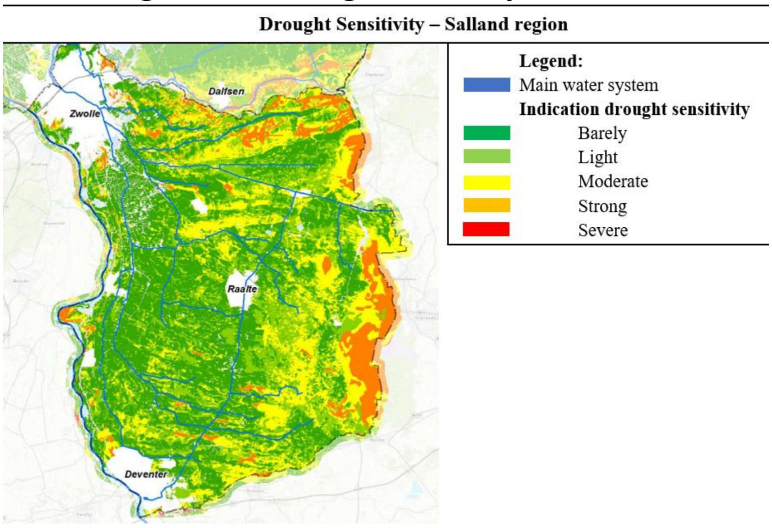
To answer the final sub-question, the 12 semi-structured interviews are used to test the assumption made that more recent experience will lead to more SWMP. Here, I compared the degree of experience of a farmer to their degree of SWMP implemented. Sub-question 2 provides a deeper understanding on how experience influences this implementation through the effect of experience on the other decision-making factors. The expert interview about ZON also provided greater detail about this relationship.

## 3.2 Case and respondent selection

### *3.2.1 Case selection - The Salland region*

The Salland region is selected since it is an agricultural area that is more prone to droughts than other parts of the Netherlands. Salland is a region with ill-defined borders, therefore, for this thesis, there is opted to use the district Salland of the Water Authority Drents Overijsselse Delta [WDOD] as depicted in Figure 3.1. Drought is likely to impact Salland more severely and sooner than other parts of the Netherlands because the east (as well as the south) of the Netherlands are home to high, sandy grounds, whereas the west mostly consists of marine and fluvial clay grounds (Dutch National Institute of Public Health and the Environment [RIVM], 2012). These areas depend on different water supply systems as well. The Western part of the country is supplied with water from the main rivers the Meus and the Rhine. The East and the South are not supplied by these rivers, making these areas fully dependent on rainfall and groundwater (WDOD, 2021). Areas within Salland have difference in sensitivity to droughts, therefore, farmers in Salland likely have different experiences with drought. The east of Salland has high and sandy grounds, this results in a dryer area than other parts of Salland. The west of Salland is lower and has access to water from the rivers Ijssel and the Vecht. This difference leads to a difference in drought sensitivity of the area, which can be seen in Figure 3.1. Farmers in drought-sensitive areas likely have more experience with droughts. Furthermore, the Sallandse Heuvelrug houses water subtraction areas by water drinking companies, surrounding farmers are thus likely to be more familiar with drought. The region of Salland thus likely has farmers with different degrees of experiences with drought.

Figure 3.1 – Drought sensitivity in Salland




*Source:* Adapted from WDOD (2021)

### *3.2.2 Population – Dairy farmers*

The population chosen from the area is restricted to one type of farmer, to make the cases as similar as possible while differing in the independent variable ‘experience with drought’. To secure enough possible cases, I used desk research to investigate which types of farm are common in the area selected. These types of farms were then compared on water usage levels; I selected the farms that on average use most water. This enlarged the possibility that drought will have directly impacted the selected farms.

Salland, alike the rest of the province of Overijssel, consists of around 70% of agricultural land. Agricultural enterprises in the region are for 95% enrolled with grassland and livestock feeding (e.g., maize tillage); 78% with grazing livestock, most of which cattle; and 22% with arable farming (54% potatoes, 26% grains, 15% sugar beets, 5% other) (Dutch central statistics office [CBS], 2021a;2021b). The other types of agricultural enterprises have a significantly smaller share. As can be concluded from this data, most enterprises are enrolled with mixed types of agriculture. These numbers show that the agricultural sector is dominated by cattle-farming and grassland.

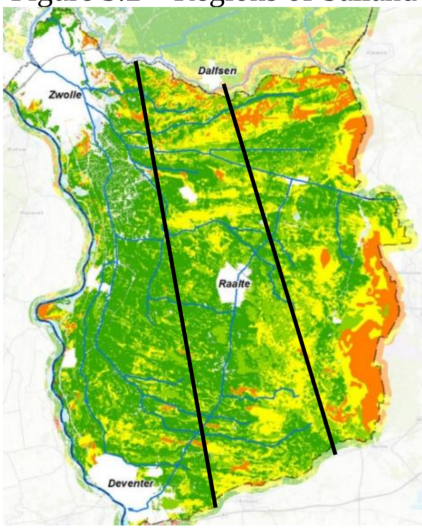
Most dairy farms produce a part of their own roughage, which is grassland and maize. To analyse which type of farm uses most water, and thus likely is most affected by droughts, the different water footprints of the most farmed products can be analysed. For maize and grassland, farmers increasingly opt for sprinkler irrigation from wells during the dryer months in summer (de Nieuwe Oogst, 2022). Sprinkler irrigation is seen as unsustainable when it is used in high amounts, as it depletes the groundwater level further (Hoekstra, 2020). By reducing evapotranspiration, drip irrigation increases water productivity as compared to sprinkler irrigation (Hoekstra et al., 2011). This can lead to 40% less water consumption when drip irrigation is used instead of sprinkler irrigation(Bayer, 2022). However, for grassland and maize tillage, this practice is uncommon, as drip irrigation is still too expensive for these relatively cheap crops.

For arable farming, grains, being even cheaper than maize, are rarely irrigated. Potatoes sometimes are irrigated with sprinklers, but increasingly this is being done through drip irrigation (De Nieuwe Oogst, 2022). Potatoes are more expensive, and therefore, the investment in drip irrigation is more feasible. According to UNESCO (2009), on average, potatoes require 200 litres of water per kg of produce, whereas this is 870 litres for maize. These global averages may not correspond to the context in the Netherlands. Nonetheless, the big difference between these two crops makes it unlikely that potatoes require more water than maize in the Netherlands. This relative high reliance on groundwater makes dairy farms likely to be more affected by droughts. For this reason, combined with the dominance of this farm type, this thesis focusses on dairy farms.

### *3.2.3 Interviewee selection*

For the interviews, the sample aimed to include an equal representation from different areas in Salland, as they are differently affected by drought and thus expected to have a different experience with drought. The areas are visualized in Figure 3.2.

Figure 3.2 – Regions of Salland




*Source:* Adapted from WDOD

Because the cases are most similar in farm characteristics, comparison of the effect of the independent variable ‘experience with drought’ on the dependent variable ‘implementation of SWMP’ is possible. The units of analysis and observation both are individual farmers. The inclusion criteria are provided in Figure 3.2.

Table 3.1 – Inclusion criteria for farmer interviewees

| Inclusion criteria | Reason |
|---|---|
| Main type of farm: Dairy farm | Salland is home mostly to dairy farms, and these farms require relatively high levels of water usage. By selecting one type of farm, cases are more similar and easier to compare the effect of the independent |

| | |
|---|---|
| | variable ‘experience with drought’, as it is less likely that farm differences are causing this effect. |
| The interviewee is the sole owner of the enterprise, in charge of the decisions related with SWMP, or the enterprise is a family business, all included in water related decision-making should be present for the interview. | By only selecting farm owners, as opposed to workers, the interviewee will be in charge of decisions related to the implementation of SWMP. |
| Farms must produce their own roughage feed. | The farms produce their own roughage feed, as this was shown to be the main reason why dairy farmers need water. |
| The farm must be mid-size: with a minimum of 50 dairy cows, and a maximum of 150 dairy cows. | The average of the Netherlands number of cows is 103 (Wageningen Economic Research, 2021). Agrimatie (2018) stated that farms are considered small with less than 50 cows, and large with more than 150 cows. |
| Equal number of farms from each of the three areas in Salland | The areas are differently affected by drought and thus will have a different experience with drought. |

In addition to the farmers, the interviewees also involved experts in the area of water governance. These experts were interviewed regarding their opinion and knowledge about farmer incentives and decision-making, as well as their opinion about the water governance setting and regulations. The experts selected for this purpose are from the water authority WDOD and from Province of Overijssel.

### 3.3 Data collection

Data was collected through semi-structured interviews with farmers and document analysis. For the document analysis, I searched online for relevant policy documents. 14 policy documents of the Dutch national government, the province of Overijssel, the WDOD, and Vechtstromen were analysed, as well as the online archives and the websites of these organisations.

To select interviewees from the defined population I used purposive sampling. Studies show that the first 6-10 interviews yield about 80% of the total data, data saturation occurs between the $8^{th}$ and $16^{th}$ initial interviews (Guest et al., 2006; Coenen et al., 2012; Namey, et al., 2016). Based on this information, the sample was set at 12 interviews. I used purposive sampling because it enabled me to select cases that are most likely to differ in their experience with drought. This makes enables comparing these cases on their SWMP implementation in relation to this experience.

These interviews are based on the questions in Appendix C. Not all questions needed to be asked, but the different dimensions must be touched upon. For example, when answering question 6, the interviewee might already answer question 10. I asked for further clarification or elaboration of dimensions when deemed necessary. Opting for a semi-structured interview ensured that all relevant dimensions of the different variables were covered and comparable across cases (Kakilla, 2021). Simultaneously, by maintaining a flexible and open structure, interviewees could address and deepen topics that they considered important. This can lead to different and deeper insights than would be obtained through structured interviews alone. The interviews were used to gather data on farmers' perceptions of the factors identified as influencing farmers’ decision-making, as well as their experience of drought and their SWMP implementation. By choosing a qualitative method of data collection, it was possible to go in-depth into the relationship between experience, decision-making and SWMP implementation.

The interviews were recorded and transcribed, with both the interviews and transcription conducted in Dutch, the native language of both me and the interviewees. Transcription and data analysis were also done in Dutch. Different codes were created for all variables based on their dimensions (e.g., denial and belief (in climate change)), these codes were first applied deductively. During a second round of coding, the codes were inductively revalued, removed and added when the codes do not seem to cover the answers well enough. At this stage, I related the codes to the factors identified for farmers' decision-making, and translated them to English. Table 3.2 shows which data is collected per sub-question.

Table 3.2 – Data Collection per subquestion

| Sub-question | Data needed to answer | Data collection methods |
|---|---|---|
| 1. What actors and policies are included in the water governance and management context in Salland in relation to drought in the agricultural sector? | List of actors<br>List of policies | 1. Document analysis<br>2. Expert interview WDOD<br>3. Expert interview ZON |
| 2. How does experience with drought affect the farmers' decision-making process in implementing sustainable water management practices? | List of farmers' decision-making factors (see section 2.5)<br>Information on how farm and societal level factors impact farmer level factors | 1. Farmer interviews<br>2. Expert interview WDOD |
| 3. How does experience with drought affect the degree of implementation of sustainable water management practices by farmers? | Information on drought experience of the different farmers, and the SWMPs they have implemented.<br>Information on when and why they implemented these SWMPs. | 1. Farmer interviews<br>2. Expert interview ZON |

Table 3.3 shows the overview of respondents. Due to the current Nitrogen-crisis, most farmers were hesitant to agree to the interview, this resulted in the inclusion of two small-scale, extensive farmers to get closer to data saturation. When discussing the results, these farms are specifically mentioned if they seem to differ from the general patterns. All the interviewees were men, on one occasion, a woman joined her partner during the interview, as she also was involved through a family cooperation in water management. With quotes, the respondents' code number is given to guarantee their anonymity.

Table 3.3 – Interview respondents

| Code | Salland region | Type farm | Number of cows | Date interview |
|---|---|---|---|---|
| 1 | West | Single owner | 150 | Nov '22 |
| 2 | East | Single owner | 120 | Dec '22 |
| 3 | East | Family business | 125 | Dec '22 |
| 4 | Central | Family business | 125 | Nov '22 |
| 5 | Central | Single owner | 100 | Nov '22 |
| 6 | West | Single owner | 125 | Dec '22 |
| 7 | Central | Family business | 55 | Nov '22 |
| 8 | Central | Single owner | 95 | Dec '22 |
| 9 | East | Single owner | 60 | Nov '22 |
| 10 | East | Single owner | 40 | Dec '22 |
| 11 | East | Single owner | 70 | Dec '22 |
| 12 | West | Single owner | 22 | Nov '22 |
| Board member WDOD | | | | Nov '22 |
| Province Overijssel – ZON expert | | | | Dec '22 |

### 3.4 Operationalising of the variables

The different variables identified consisted of several dimensions. For each variable, I constructed an indicator in the form of a question. This question also covered the different dimensions of that variable. Asking questions about the variable, rather than the dimensions, allowed interviewees to talk about what first came to mind. This was considered to be an indicator of the importance of the different dimensions for that interviewee. The interview structure and questions can be found in

Appendix C. The interviewer decided whether the answer sufficiently covered all dimensions, or asked for clarification of the different dimensions.

**3.5 Data analysis**

To analyse how experience with drought affect the farmers' decision-making process in implementing sustainable water management practices, there were multiple categories created for each of the factors identified in the literature review. I asked one or more questions for each of these factors. The second round of coding yielded the codes in Appendix D. These codes were used to qualitatively assess how the respondent ‘scored’ on each of the factors identified. Examples of this are noted in the ‘Examples’ column in Table 3.4. The second part of Appendix D shows the ‘final’ codes used in the analysis and comparison of the respondents. The codes of the second round were used to explain relations found in the data analysis.

Table 3.4 - Indices for measuring farmer decision-making factors

| Factor | Question | Range | Examples |
|---|---|---|---|
| Belief in climate change | 3 | Strong belief | *“It has been noticeable for years, it is getting dryer”* |
| | | Doubting | *“Whether or not because of climate change, there is less rain”* |
| | | No belief | *“I do not think this will persist (...), we also had dry years in the past”* |
| Internal adaptive capacity [IAC] | 5, 8 | Strong IAC | ‘Beliefs damage can be avoided’ ‘Previous successfully adapted’ |
| | | Medium IAC | ‘Damage can be partly prevented’ ‘Previously partly successful adapted’ |
| | | Low IAC | ‘Only irrigating will help’ ‘Unsure if possible to continue under drought’ |
| | | Limiting IAC | ‘Against real droughts, nothing will help’ ‘No adaptation intention’ |
| Risk perception | 4 | High risk perception | ‘Sees necessity to adapt to avoid damage’ ‘Expects new damage’ |
| | | Medium risk perception | *Combination high and low risk perception indications* |
| | | Low risk perception | ‘Does not think adaptation needed, for no damage expectation’ |
| Agroecosystem | 6 | Enhancing drought risk | ‘Sandy’; ‘High ground’ |
| | | Neutral | *Combination enhancing and limiting drought risk indications* |
| | | Limiting drought risk | ‘Ditch available’; ‘Nearby river’ |
| External adaptive capacity | 5, 11, 13 | High EAC | ‘sees SWMP options’; ‘Knows POP3/ZON subsidies’ |
| | | Medium EAC | *Combination high and low external adaptive capacity indications* |
| | | Low/ No EAC | ‘Sees no possibilities’ |
| Institutional setting | 11, 12 | Enabling | ‘Policies led to decreased damages’. |
| | | Neutral | *Combination enabling and hinderance institutional setting indications* |
| | | Hinderance | ‘Policies lead to postponing investments’ |
| Societal setting | 14, 15 | Enabling | ‘Knows of measures through network’ |
| | | Neutral | *Combination enabling and hinderance social setting indications* |
| | | Limiting | ‘Finds social discourse judging’ |

To analyse how experience with drought influences the degree of implementation of SWMP, typologies were drawn up for both drought experience and sustainable water management. Each case is assigned to one of the categories in the typologies. I examined the relation between type of experience and degree of implementation through analysing the relation between the categories of both typologies, can be examined. Table 3.5 shows how cases are classified in the categories of the typologies. The last row shows the experience typologies categories used for analysis.

Table 3.5 - Category classification typologies

| **Implementation of SWMP -** Question 7 | | | |
|---|---|---|---|
| **SWMP category** | **Diversity of measures** | **Permanence of measures** | |
| Highly drought resilience enhancing SWMP | 3+ different measures | At least one structural | |
| Mildly drought resilience enhancing SWMP | 2+ different measures | At least one semi-structural | |
| Weakly drought resilience enhancing SWMP | Singular measure | (semi-) structural | |
| No drought resilience enhancing SWMP | None to multiple measures | Only short term | |
| **Type of drought experience –** Questions 1, 2 | | | |
| **Severity (personal impact and duration)** | | **Frequency** | |
| Codes for severity were in three categories (financial damage; damage control costs (e.g., no damage through irrigation); and crop damage). Some had insignificant impact, or were even advantaged. Severity was then assessed as an overall picture per farm along these dimensions, when it was difficult to assess from the codes, the transcript was analysed for words the respondent used to describe it. | | Frequent is 3 or 4 (4 droughts since 2018) Not frequent is between 0 and 2 droughts. (Earlier droughts do not count as frequent, as these will not affect affective emotions because of the temporal distance (Grothmann and Patt, 2005)) | |
| Severe, Frequent Drought Experience [SFDE] | Severe, Infrequent Drought Experience [SIDE] | Insignificant, Frequent Drought Experience [IFDE] | Insignificant, Infrequent Drought Experience [IIDE] |

Overall results are presented by theme (experience, implementation of SWMP, decision space, farm level factors). Findings are supported by quotations or text fragments. To identify causal links, cases with different drought experiences are compared, as well as changes within cases, if any.

*Validity and Reliability*

The research is evaluated in terms of validity and reliability. Content validity assesses whether a test is representative of all aspects of the construct (Babbie, 2013). This is covered by determining the dimensions, indicators and measures based on relevant previous research on drought experiences and farmers' decision-making. Internal validity is defined as the extent to which the observed results represent the truth in the studied population, and thus are not due to methodological errors (Babbie, 2013). For this, questions are included that refer to the temporal dimension between independent (drought experience) and dependent (implementation of SWMP) variables. To ensure that the dependent variable indeed is caused by the independent variable, there was furthermore directly asked how farmers themselves perceive the impact of experience on their water management practices. External validity refers to the generalisations of the conclusions of this study and in what way they are usable in other situations (Babbie, 2013). This study is a small-n research among dairy farmers in Salland, therefore the conclusions cannot be derived outside this context, but can be transferred to similar settings. The findings explore the relationship between drought experience and SWMP implementation in a different context than most studies in the field. Results therefore add to the understanding of farmers' decision making and the related factors. Subsequent studies should be more quantitative in nature to test whether these conclusions are useful in other contexts.

Reliability refers to the repeatability of the study, given the proper measurements (Babbie, 2013). One possibility is the misunderstanding of concepts and questions used in the interviews between the interviewer and the target group. Therefore, the questions are adapted to concepts used by the target group itself (based on the information on the websites of LTO, the water authorities and the Agricultural Nature Organisations. Furthermore, all interviewees received an explanation of how drought is defined in this thesis, before the start of the interview. The interviewees were only asked questions about their personal experience. In addition, the interviewer asked for clarification when answers could be interpreted in multiple ways or when the farmer expressed doubt.

### 3.6 Ethical considerations

This section deals with the ethical aspects of the thesis study. As the interviews are conducted among individuals, a request was sent to the Faculty of Behavioural, Management and Social Sciences [BMS] ethics committee before conducting this research. Individuals were made aware that they were free to choose whether or not to be interviewed, that no reward would be given for their participation, that they could refrain from answering a question, and that they have the right to have their data deleted if they change their mind during or after the interviews. Interviewees were asked to agree to which data will be collected and how this data will be stored; the use of anonymised direct quotes in the results section; the interview being recorded by the interviewer.

After the interview, a written transcript was sent to the participants that indicated they wanted that. After confirmation of the transcript, the collected data was stored with personal codes that are separate from their interview number, instead of identifying information. The data discussed in the results section is discussed using these personal codes. Direct quotations are only identifiable by the interviewee concerned.

The methods are in accordance with the General Data Protection Regulation. This means that research participants are aware of how much of, and how their data is stored. Personal data is treated confidentially. This information is only be used for this research and will remain only until it is no longer required. If the report is shared outside the university, only the general results will be shared. The interviews with any confidential information will not be shared. This treatment of confidential information and data complies with the UT Data Storage Policy.

# 4. Results

In this chapter the results are presented per sub-question. First, the results related to the actors and policies related to water management in Salland are shown. Then the categories of drought experience are explained, and the influence of drought experience on the decision-making process is analysed. Finally, the relationship between drought experience and SWMPs is explored.

## 4.1 Agricultural water management context

The Agricultural Water Management context is diverse and complex, consisting of multiple actors, at different layers of society, as well as a variety of policies and responsibilities concerning these actors. Below, first the responsibilities of the different actors are displayed, before assessing the policy context. The opinion of farmers about this setting is analysed and supplemented with expert-knowledge in sub-section 0.2.3.

### *4.1.1 Water management in a multi-actor setting*

Water management in the Netherlands is the responsibility of multiple actors. The district water boards, combined with the Rijkswaterstaat (Dutch water authority) together are responsible for the water management. For this, they collaborate with the provinces and municipalities (Ministry of General Affairs, 2019). In the region of Salland, as defined in this thesis, the WDOD is the only water authority involved. An overview of the different water management actors related to the agricultural sector, is given in Table 4.1.

Table 4.1 – Task and organisations of the Dutch Water Management system

| **Responsibility** | **Organisation** |
|---|---|
| Water quantity and quality (Nation-wide system) | Central government – Ministry of Infrastructure and Water Management [MIWM] |
| Water quantity and quality (regional); Wastewater treatment | Water Authorities (Public) Salland: WDOD |
| Drinking water supply | Drinking water companies (semi-public, e.g, Vitens) |
| Groundwater | Provinces: (Salland lies in the province of Overijssel) |
| Surface and groundwater level, water quality | Individual farmers |
| Stimulating sustainable practices through well compensation | Dairy factories and cooperations; (international) food retailers; consumers; Rabobank; Central government – Ministry of Agriculture, Nature and food quality [MLNV] |
| Stimulating well compensation for farmers | Politics; Non-Governmental Organisations (e.g., Milieudefensie); LTO; MLNV |
| Distribution of knowledge drought-measures and subsidies | Journals; LTO; Individual farmers; Agrifirm; Rabobank; MLNV; ZuivelNL |

*Source:* Dutch Water Authorities (2017); LTO Nederland (2020); LEI (2009); Marverick Advocaten BV (2022)

In the second half of Table 4.1, mostly informal actors and informal responsibilities are shown. Although not formal actors in water management, farmers are included since they cooperate closely with the other actors in executing their land management, which has a major impact on water quality and water levels. They are one of the main stakeholders of water usage. Because the actors all govern a part of water management, and the nature of water as a scarce resource with multiple usages, there are likely conflicts between the interests of the stakeholders. This is especially true when actors are reliant of the same water at the same location. In Salland, an example is the Vitens, pumping groundwater from areas where farmers also rely on the groundwater for irrigation. This conflict also hinders implementation of SWMP, as the farmers sometimes do not feel ownership over the problem of decreasing groundwater tables and point to Vitens: "*I do not know what I should do, well, Vitens, they should stop extracting" (Respondent 3).*

What stands out in Table 4.1 is that the creation and distribution of knowledge is mainly the responsibility of semi-public and private cooperations and institutions. The LEI (2009) states that 'the information services to the agricultural sector have been privatised'. The government is thus not responsible for providing farmers with needed knowledge for a sustainability transition. This is also noted by the expert from the province of Overijssel: "*See, as a province, you don't really advertise or anything like that, that goes, you make the money available (...) when it comes to water management on farms, mainly the LTO is an important spokesperson for us*". Moreover, information provision is fragmented across multiple instances, often depending on the initiative of farmers themselves. This view is shared by the expert from the province, who, upon asking about the coverage ratio of the LTO noted the following *"by no means all farmers are members of the LTO anymore, so that will also, that also factors in how you can reach people" (ZON expert).* The results of the farmer interviews indeed showed that those farmers aware of subsidy possibilities either had an ancillary-function, or had been in contact with the LTO.

#### *4.1.2 Water and drought policies*

Regarding the water policy, the National Water Plan is one of the most important Dutch documents, setting out the outlines, principles and directions of the national water policy (Ministry of General Affairs, 2015). However, this plan focusses on the historical water abundance and prioritises flood protection strategies in the south-western parts of the Netherlands. In response to the severe drought of 2018, the MIWM commissioned a rapport on droughts in the high and sandy grounds of the Netherlands to give advice on how to accelerate the Delta Plan freshwater objective to be more resilient against drought. The MIWM (2019) advises the agricultural sector to enhance cooperation with agricultural stakeholders to improve climate adaptive agricultural practices, to select drought and flood resilient crops, use water sufficient irrigation, water retention strategies, and to increase soil quality.

In case of a drought, the Dutch water authorities can activate the 'Verdringingsreeks (displacement schedule)' to regulate access to water (Ministry of Infrastructure and Water Management, n.d.). This schedule indicates which water uses and users will be given what priority to regulate the available water. It can be decided to ban surface water abstraction activities for the sake of irrigation in the agricultural sector if deemed necessary to sustain other water usages. Table 4.2 shows the users per priority levels of the displacement-schedule. It shows that water for agriculture is in the lowest priority level, therefor, during drought, farmers are among the first to receive a water ban. This further enlarges the vulnerability of farmers to drought.

Table 4.2 - Displacement schedule and priority levels

| **Priority 1**<br>Safety and prevention irreversible damage | **Priority 2**<br>Utilities (related to water supply security) | **Priority 3**<br>Small-scale high-value water use | **Priority 4**<br>Other interests (economic consideration, including nature) |
|---|---|---|---|
| Stability of flood defences | Drinking water supply | Temporary irrigation of capital-intensive crops | Shipping;<br>Agriculture;<br>Nature;<br>Industry;<br>Water recreation; |
| Prevention of settlement (peat and raised bog) | Energy supply | Processing of industrial process water | Inland fishing;<br>Drinking water supply (other than supply security); |

| | |
|---|---|
| Nature, insofar as irreversible damage is concerned | Energy supply (other than the supply security); other interests. |

*Source:* Adapted from MIWM (n.d.)

To make farms more sustainable or not is within the authority of farmers themselves, the national government has multiple incentives in place for farmers to transfer to more sustainable agricultural practices. According to the ZON expert, The first part of the ZON project focussed on small-scale private measures farmers (among others) could take to become more drought-resilient and to improve water quality. The distribution of these funds was in hands of the LTO, which received funding for the DAW project from the ZON project. The first part continues till mid-2023. The second part will take a more area-oriented approach.

According to the Netherlands Enterprise Agency [RVO] (2022a), farmers can join multiple projects aside of the DAW project. In these projects farmers can cooperate with the state to increase their ecological contribution, but none have a specific focus on drought-resilience. Furthermore, farmers willing to use some of their land as nature areas, to invest in innovation and more ecological-friendly machines or practices, or that are willing to participate in research, can apply for several subsidies, the most suited of which for enhancing drought resilience is the '*agricultural development programme*' [POP3] (RVO, 2022b). As stated before, these are all voluntary measures.

Specific for water-subtraction areas for drinking water, there is a 'drought damage compensation', handed out from the drinking-water company. In Salland, there are three of these areas. Indeed, farmers within these areas indicated that they received this compensation. An overview of these policies and actors is provided in Table 4.3.

Table 4.3 – Policies and responsible organisations

| **Policy** | **Policy Objective** | **Responsible Organisation** |
|---|---|---|
| Displacement Schedule | Ban specific usages of water (e.g., irrigation) to secure drinking water and water for nature in times of severe drought. | WDOD |
| National Water Plan | Efficient and Economical water consumption | MIWM |
| Delta plan Freshwater – ZON project | Small-scale, easy private measures to enhance drought-resilience and groundwater quality | MIWM – Provinces, Water Authorities (Subsidy distributed to the LTO - DAW) |
| DAW | Small-scale, easy private measures to enhance drought-resilience and groundwater quality | LTO |
| POP-3+ | Till 40% subsidy on drip-irrigation, water level oriented drainage, creating water storage basins or weirs | RVO |
| Drought damage compensation | Provide compensation for drinking water subtraction activities | Vitens |

*Source:* MIWM (n.d.; 2015; 2021); Expert interview (2022); LTO (2013); RVO (2022b)

By only having incentive-based policies related to drought-adaptation through sustainable measures, the implementation of these policies might be slower, or less widely distributed over the sector than the government intents. Hindrances are the privatised knowledge of these subsidies, possibly limiting the awareness among the wider farmer population. Besides, by making these policies voluntarily, the farmers may be resistant to changing their behaviours and adopting new practices even with the promise of subsidies if their priorities are not with drought adaptation.

## 4.2 The influence of drought on the farmer decision making process

Before providing the results that help answer the second sub-question: *How does experience with drought affect the farmers' decision-making process in implementing sustainable water management practices?* Some information about the agroecosystem of the farmers is worth mentioning. 5 respondents specifically named to be located on high, sandy grounds, 4 of them said to be located lower, and either had sandy, or peat soils. The other three respondents did not specifically mention the 'height' of their location, but only mentioned they had sandy soils.

The classification of the different farmers into the typologies of SWMP and drought experience is shown in Table 4.4. The codes are similar to those in Table 3.3.

Table 4.4 - Classification of farmers and their farms

| Code | Drought classification | SWMP classification | Height farm location | Soil farm location |
|---|---|---|---|---|
| 1 | IFDE | No SWMP | Low | Peat and Sand |
| 2 | IFDE | High SWMP | *Not named* | Sand |
| 3 | SFDE | High SWMP | High | Sand |
| 4 | IIDE | Mild SWMP | Low | Sand |
| 5 | SFDE | Weak SWMP | *Not named* | Sand |
| 6 | IIDE | Weak SWMP | Low | Single owner |
| 7 | SIDE | Weak SWMP | High | Peat |
| 8 | SFDE | Mild SWMP | *Not named* | Sand |
| 9 | SFDE | High SWMP | High | Sand |
| 10 | SFDE | Mild SWMP | High | Sand |
| 11 | SFDE | High SWMP | High | Sand |
| 12 | IIDE | No SWMP | Low | Sand |

In the the column 'Drought classification', the different drought experience categories, as explained in Table 3.5 are displayed. (Severe, Frequent Drought Experience [SFDE], Severe, Infrequent Drought Experience [SIDE], Insignificant, Frequent Drought Experience [IFDE], Insignificant, Infrequent Drought Experience [IIDE])

Below, first the influence of the agroecosystem on drought experience, and differences in drought experiences among the respondents are discussed. Thereafter, the influence of drought experience on farmer level factors is analysed. Then the influence of drought experience on farm and societal level factors are discussed. Finally, the relation between drought experience and (S)WMP implementation is analysed.

### *4.2.1 Drought experience*

This section shows the results related to the drought experience of the farmers. It displays the influence of the agroecosystem on this experience and examines the different dimensions of drought experience, namely severity, frequency, and duration of drought. The classification of farmers in drought experience categories is as follows: 6 farmers had severe and frequent experience, 1 had severe but infrequent experience, 2 had insignificant but frequent experience, and 3 had insignificant and infrequent experience.

*Agroecosystem, a tell-tale sign*

The drought experience of the farmers differs related to where they are located and some key agroecosystem characters. There might be a relation between severity and frequency of droughts experiences, and the agroecosystem. As can be seen in Table 4.5. The numbers correspond to the number of farmers included in that context.

Table 4.5 – Relationship between agroecosystem and drought experience

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **Risk enhancing Agroecosystem** | 4 | 1 | | |
| **Neutral Agroecosystem** | 2 | | 1 | |
| **Risk limiting Agroecosystem** | | | 1 | 3 |

Farmers that face a risk enhancing agroecosystem also have the most severe and frequent experience. Differences between a risk enhancing, or a limiting risk agroecosystem are found in the height of their land (high or low), whether they have access to an irrigation ditch, and the level of the groundwater. Soil type did not matter as much, as most of the farmers had sandy soils, regardless of their drought experience. That location matters is clear from the following statements:

> *You see, the water level is so low on the hill in the summer, I mean, if everything is full you can store it for longer. But the water level is below 3 meters you know. That is very low, and then you can't actually grow crops from groundwater, it is impossible, crops do not grow roots that long (Respondent 10).*

> *Last year there was no drought, and before that, well, my land is pretty low here. So it is more difficult during wet periods, (…) You need to experiment a bit, but with the drought of this year, the best yield was there, on the low areas, so to speak (Respondent 12).*

*Determining frequency, severity, and duration*

Related to the agroecosystem is the frequency of droughts endured, it seems that those farmers that did experience the drought of 2018, also experienced droughts in the subsequent years. Whereas those who did not face severe droughts were also most likely to have infrequent experiences. This can be seen in the following numbers: 6 people endured severe droughts at least 3 of the 4 times, whereas only one faced 1 severe drought, and insignificant drought impact in the rest of the years.

Drought impacts occur in many different ways and often are not identifiable by a single number known by the farmer. During coding, there were distinguished three main branches of impact, financial impact (e.g., having bought a sprinkler installation; having to buy feed; or field-restoration costs), damage control costs (e.g., stock drawdown, irrigation), and crop damages (e.g., lower quality and quantity yield; increased weed pressure). Besides these categories, there were also farmers that either were not affected, or even benefitted from the drought periods. The last quote above is an example of that. Aside of these impact categories, another way to determine significance is through emotions expressed by the farmer. The following statement shows different aspects of significance, as well as the impact of frequency.

> *Those seeds are very expensive, and these soils, I work them myself, you need to plough, to shred. All in all, maize is a very expensive crop. And then, if you see it drying out and dying, and you know what more. Well, that actually hurt. It has happened to me 2 or 3 times more you know. (...) So I decided I needed to have one (sprinkler installation) myself, so I bought one. But in the end, it is hard to say if the costs outweigh the benefits. I think so (Respondent 3).*

Within active memory of the farmers, there was both a multi-year drought (2018-2020) and a one-season drought (2022). Therefore, it was possible to analyse how the duration of drought affected farmers. For within one growing season, farmers generally indicated that once the drought got into the crop, all damage was done anyway, and how long a drought would succeed thereafter did not matter. "*By the time we thought, we really need to irrigate, we were too late, so it would not matter anymore" (respondent 1).* There were indications however that duration of drought, in the sense of spanning multiple successive drought seasons did matter.

### *4.2.2 Effect of drought experience on farmer level*

This section focuses on the results related to the second sub-question. First, the results on the decision factors *within* the farmers decision space, and then the effects of drought experience on the other related factors are presented.

*Belief in climate change*

The theoretical framework showed that experience with drought impacts the farmer decision space in several ways. Namely that severity impacts risk perception, and frequency impacts IAC. However, data review showed that frequency of drought experience also affects belief in climate change. There are fewer feelings of doubt about climate change when farmers were frequently exposed to drought. 6 out of 8 with frequent exposure stressed their belief in climate change, the other 2 expressed some doubts, but were inclined towards climate change. How many of these doubters felt is seen in this statement: "*Well, you know, you could say it is because of climate change. (...) Could be, but well, it is a fact, whether or not caused by climate change, that there is less rain, much less" (Respondent 9).*

Of those without frequent experience only 1 out of 4 did express strong belief, and 1 denied climate change. Significance seems to have a weaker impact on belief than frequency. 4 out of 7 expressed strong belief, all other 3 had doubts. Compared to 3 out of 5 for those with insignificant experiences. For those with frequent drought encounters and belief in climate change, the following statement catches their feeling well:

> *Climate is an issue though. It is becoming, it is changing. It is getting warmer, less volatile, we used to have nice weather, rain, and nice weather again. I have the feeling that now, these last few years, either droughts are very, very prolonged, or it stays wet for a very long time. (Respondent 3)*

*Risk perception*

Besides belief, drought experience influences risk perception. The pattern is clear from the drought typology, as shown in Table 4.6. Here, almost all farmers with Severe, Frequent Drought Experience felt high risk, while all farmers with Insignificant, Infrequent Drought Experience felt no to low risk. Also noteworthy is that this table largely corresponds with Table 4.5. The respondents in all categories are the same. It can therefore also be stated that the agroecosystem indeed almost directly contributes to risk (perception).

Table 4.6 – Drought experience related to risk perception

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **High risk perception** | 5 | 1 | | |
| **Medium risk perception** | 1 | | 1 | |
| **Low risk perception** | | | 1 | 3 |

However, the framework proposes that severity matters more to risk perception than frequency and indeed, those with severe experience, regardless of the frequency of exposure felt medium to high risk. Whereas there were also farmers with insignificant, but frequent experience that had low risk perception. The following statement carries the idea of those who feel no risk and had an insignificant drought experience. "O*f course, it can get dry for a while, but risk from drought?(...) in our area, it is not so bad" (respondent 4).* This quote greatly differs from the feeling of those who had suffered severe drought impact. They have a high risk perception. In fact, half of the farmers that expected new damage of droughts also expected that no measure would be sufficient in preventing all damage. A thought well captured by this quote: "*No, no, you cannot prevent all damage, certainly not, at some point, as during this summer, that was extraordinary, warm, and a long period of drought, and then you cannot, no, you have damage no matter what you do, but you can try to limit it" (Respondent 8).*

*IAC*

According to the theoretical framework, frequency does matter to the IAC of a person. Especially to its dimensions of self-efficacy belief, adaptation intention, and former mal-adaptation. However, as shown in the quote above, self-efficacy belief may decrease when faced with several years of severe damage. None of the farmers stated that the measures would be fully sufficient to cancel out all negative effects of droughts. The data-analysis showed varying IAC's for those farmers with Severe, Frequent Drought Experience. Those who tried taking innovative measures experienced difficulties in execution of the measures, or found the effect having been too little to make a real difference. The quotes below give two examples of differences in IAC, and the struggles with adaptation while both respondents have similar drought experiences.

> *It is a bit of an experiment, a bit of 'how does it work?', 'I did not expect this' and I thought, 'how did this happen?', I had one area where I thought I had it right, so I went to check and that old culvert, made of plastic had started to flatten, so the mould did not fit anymore, you could see it had come loose. So that was something alike, I had inflated that thing and worked the soil, and I had the water there and then I thought, 'how did this happen now?', it cost me quite a bit, yes it did. (respondent 9)*

> *Respondent 3 on drought-resilient maize: I did that, yes, but it is so hard. I always say it like this, all crops can handle a bit of drought, but to droughts alike the last couple of years, no crop can withstand that. It does have effect though, (…)However, there are limits, look, droughts as we have currently, nothing can withstand that. All crops need something.*

Aside of (mal)-adaptation. It was found that frequency impacts adaptation intention. This is especially true for those farmers who sold their sprinkler installation since they deemed it unnecessary in the Dutch climate. Many do not have the intent of re-purchasing such an installation, due to the high investment (between 60.000-80.000 euros) they need to make for that. For those with infrequent drought experience, a shared feeling is that buying feed will be cheaper than the investment in the long run. However, after 2020, 3 have bought a sprinkler installation, those three had both high frequency and severe drought experience. 2 have this intention in the near future, they both have Severe, Frequent Drought Experience. The fact that frequency matters is underscored by this statement: "*if you had been here in 2016, I would have said 'ah, it is not that bad really, sometimes we have a dry year, but in general, the Netherlands has a lot of, and often rain'"(respondent 8).*

That the recent droughts have impacted adaptation intention was also noted by the ZON expert. He noted that the application for water-quantity measures increased after 2018. According to the ZON expert, due to the recent droughts, it is easier to convince farmers of the need of drought adaptation, as they already are aware of the risks. It seems that not frequency, but duration of droughts matter most. This mainly has to do with storage. Farmers tried to keep at least half a year feed in storage to weather seasons of low yield. Successive seasonal droughts (as with the multi-year drought) require farmers to de-stock without the opportunity to refill this storage. Therefore, drought hits more severely after the first year of drought. This sentiment is shared by another farmer: "*So we were already a bit tight then, and if you then again have a dry year, (…)no we should absolutely not have another dry year, I even hope I can make it till 1 May with what I have left" (Respondent 2).*

It is clear that drought experience indeed affects how farmers consider or look upon the options they see. However, aside of the relations pre-supposed through the theoretical framework. It was found that drought experience also relates to some of the other decision influencing factors. These results will be discussed in the next paragraphs.

### *4.2.3 Effect of drought experience on farm and societal levels*

*External adaptive capacity and mal-adaptation*

For external adaptive capacity, or, being aware of measures one can take to enhance drought-resilience, there is a pattern visible. In general, those farmers with less drought experience have less external adaptive capacity, while those with more drought experience have higher adaptive capacity.

However, there are two farmers that have Severe, Frequent Drought Experience with no to low external adaptive capacity, as can be seen in Table 4.7.

Table 4.7 – Drought experience and External adaptive capacity

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **High External adaptive capacity** | 2 | | | |
| **Med External adaptive capacity** | 2 | 1 | 2 | |
| **Low External adaptive capacity** | 2 | | | 3 |

Those with Severe, Frequent Drought Experience and low external adaptive capacity both already have high SWMP, meaning they already took many measures to become more drought resilient. However, they also both share a somewhat 'fatalist' view on drought resilience stating that nothing actually helps against severe droughts and losses will become more common and unavoidable. That SWMP measures, especially drought-resilient crop species, often have a disappointing yield is shared among most farmers that use these kind of crop species. Another shared feature for both of these farmers is that they do not have access to an irrigation ditch, severely limiting their options for water-storage. This 'fatalist' perception shows in the following statement: "*From where would I get the water? No, I cannot access water from here anywhere. I do not know where I should take it from. (…) I have nothing, that is the problem, I do not have water"(Respondent 3).*

A reason for the low external adaptive capacity of those with I experience is that they do not see the need for adaptation. The measure most often considered is sprinkler-irrigation. SWMP are not under consideration. This has mostly to do with that the investment in these measures does not outweigh their costs in their cases. For drought resilient crop types almost all farmers mention that they are lower in both quality and yield than 'regular' crops. For farmers with less drought experience, these crops are not considered.

That IAC and external adaptive capacity are influenced by the frequency and severity of drought experience is seen by the ZON expert as well, he specifically mentioned that knowledge, multiple droughts, and severity are important for farmers in coming to the conclusions that they need to adapt.

> *I think that is it, knowledge. And maybe also an investment decision at some point. That they (farmers) see that well, 4 years of drought have been endured, 'am I going to invest in sprinklers, or are there other possibilities, can I close ditches, what effect will that have?' That is a contributing to awareness, is it not? (…) and it might also help how big the drought damage has been, that they will consider adapting earlier on, and start exploring options.*

*Social setting*

As stated in the theoretical framework, drought experience can impact networks by increasing both IAC and Risk perception within those networks. Which then also increases in those farmers with insignificant drought experiences. All respondents indicated they had contact about drought with other farmers in their direct surroundings, however since these farmers more often than not had similar drought experiences, the proposed relation is hard to study. However, about half of the respondents indicated to be part of workshops, or to be part of a study group (not related to drought adaptation specifically), of which one has IF experience. Therefore, a relation between network and IAC or Risk perception cannot truly be derived from this study.

Networks do however seem to be important for External Adaptive Capacity through sharing both possible methods for drought adaptation and subsidy possibilities. 9 of the 12 farmers stated to be familiar with measures through workshops, journals, or through the LTO, while only 5 out of 12 mentioned their direct network to have impacted their knowledge on drought-adaptation measures. For subsidy possibilities, it is noteworthy that only a few farmers are aware of POP3, DAW, or ZON. Of these farmers, most know so through their ancillary functions (politician, agrarian consultant, board member WDOD). The final respondent knew from the subsidy since he had been investigating nitrogen measures. 2 respondents indicated not knowing of drought-adaptation subsidies, but specifically mentioned the revision of the common agricultural policy in 2023. In this policy, farmers can achieve premiums for sustainability and nature-inclusive adaptations. 6 farmers were not aware of any subsidies or premiums.

Half of the farmers, irrespective of whether they were aware of subsidies noted that if there were subsidies, they were either too restrictive, the compensation too low, or that the subsidy is available too little in comparison to those that want to use it. A sentiment that shows in this statement:

> *There are already subsidies for that, but you know, the thing with subsidies. You need to adhere to so many conditions (...) We want to cooperate, I would love too. However, when they set conditions that are not practically feasible, or that involve so many extra costs, then I say, I am not going to do it (Respondent 8).*

Indeed, also the expert from WDOD noted that subsidies for water-storage would often require ‘second’ measures to be able to apply for subsidies. These secondary measures would often need to be nature oriented. Yet he too noted that subsidy-knowledge should be more widespread, as it could benefit more farmers.

In the theoretical framework, it was furthermore found that aside of networks, social discourse impacted adaptation intention. If social discourse focusses positively on drought adaptation, farmers would be more likely to do so as well. The results of the study do not co-align with this. Nonetheless, many respondents knew about the ‘water-saving’ discourse in society. For some, this discourse was felt negatively, they stated ‘*but they judge, even though they do not know how much we already do’ (respondent 7); ‘they want us to do all these things, but in the grocery store, the wallet rules’(Respondent 1).* Indeed, around a quarter of the respondents indicated a feeling of being judged or pressured. However most interviewees indicated that this discourse did not affect their water management. They indicated that either saving their crops was more important than water saving, or that they saw the need of adaptation themselves, and that they do not need society for that.

Some also indicated that consumers, or other industries should first look towards themselves, before addressing farmers in their water use. This is especially true for those farmers in the drinking-water subtraction zones. For them, societies pressure feels unfair, as they are responsible for only a fraction of the water-subtraction, especially since the drinking-water leaves the local water system. This sentiment shows clearly in this statement: *But it actually is really twisted, that there where a Natura2000 area exists, that you export the water, from that nature area. And then people will drink it, yet the people, the locals, they must bleed for it” (Respondent 10).*

*Institutional setting – The water authority*

One interesting finding is that there seems to be a relationship between the significance of drought experience and perception of the institutional setting. Especially related to the perception of the water authority, as this is the institutional level closest to the farmers. As can be derived from Table 4.8, those with severe drought experience perceive the water authority as hindering in their attempts in becoming drought-resilient, or worsening their drought risk. Whereas those with insignificant experience perceive the water authority more often as supportive in becoming less prone to drought risk.

Table 4.8 – Drought experience and perception of water authority

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **Water authority supportive** | 1 | | 1 | 3 |
| **Water authority neutral** | | | 1 | |
| **Water authority hindering** | 5 | 1 | | |

Only one respondent with severe drought experience perceived the water authority as supportive. This respondent has an irrigation ditch, of which the water authority can change the water level. In doing so, they have previously aided the farmer in preventing losses to drought. Of the other farmers with severe experience, only one has a ditch that is under control of the water authority, but he feels that the water authority does not do anything with it to help him contain the water for a longer period. A statement heard of all farmers with significant impact from drought is *'they ask for higher payment each year, yet each year they do less'*. When asked to name what they think they are paying for, sarcastic answers were given '*for their board (Respondent 10)', 'they just fill their pockets'(Respondent 12),* or they were clueless. '*I have no clue what I pay for, I find they do not do a lot' (Respondent 3)*.

Occasionally farmers experienced true hindrance from the water authority their policy, either through the displacement schedule, or through mis-management, as this statement shows. Yet for most with negative feelings, this originates from the incapability of the water authority in helping them avoid drought-damage. Often, especially for those farmers without a ditch, the water authority is quite incapable in preventing water levels from falling during the summer. This compared with still having to pay quite a bit in taxes results in negative emotions, stemming from a feeling of unfairness, directed at the water authority. As becomes clear with this statement: "*They (the water authority) say that it is difficult to bring water into this area. But I suggested them, 'if I do not benefit from you, then at least also no costs', because see, these costs are there, I must pay them water authority taxes" (Respondent 10).*

These problems are amplified since there is often a low number of farmers in these 'hard' areas. For the water authority, projects to invest in water supply in these areas are not feasible. The WDOD expert specifically mentioned that they do not aid individuals, as their projects need to have scale. For the ones with positive experiences with the water authority, this experience originates from the ability of the water authority to avoid damage through water surplus, something the Netherlands has a long history with. Indeed, the WDOD expert noted that they are actively trying to, and achieving a good name among farmer communities: "*The neighbourhood here is quite happy with the water authority. Last year as well, they nicely pumped the water. Everybody is really enthusiastic about it. See, for us, that is really important, very important"*.

This feeling from the water authority does seem off with the feeling of those farmers in drier areas. The ZON expert was also aware of this difference and tried to explain it through the following:

> *The WDOD is quite agrarian-oriented, so you would expect these areas to favour agrarian interests. However, there is a tension between what the authority wants to do, and what it can do (...). There are areas where water is easy to bring, but in some places, this is harder. (...) In my opinion it is then because the scope of action for the water authority in the areas, since where you do not have supply, what is not there they cannot bring there either*.

This is then amplified since the displacements schedule impacts especially those areas where it is driest "*if you are then tight (on water) and that kind of water supply (to agrarians) is the first to be cut off and well that, I can imagine that doesn't fall very well then either*".

*Institutional setting – The government*

For the national government, there is no pattern visible in relation to drought experience. However, noteworthy is that most of the farmers hold a negative opinion about the national government, or the house of representatives. Only two farmers have a positive feeling about this part of the institutional setting. As explained earlier the nitrogen-policy has had huge impacts on the prospects of the agricultural sector. When discussing the governmental influence on water management, many farmers voluntarily shared about the impact of this policy, instead of water related measures. Statements that convey their negative stance are: '*nature is very important in this country, sometimes I believe they (the government) find it more important than food' (Respondent 1); 'maybe* *this is a conspiracy theory, but is sure looks as if they think "if we do this (the policy), all those farmers will quit by themselves' (Respondent 10).* Occasionally, the nitrogen-policy led to an increase of livestock instead of the objective of reducing nitrogen levels. That there is a possibility that the current nitrogen policy will harm implementation of drought adaptation measures is also seen by the ZON expert "*Just what are the effects of everything to do with nitrogen, on, well, those measures, and whether farmers are still willing to invest in those measures? Yes, that is still quite an anxious question. We will need to find that out in the coming period".*

When it came to water policy specifically, statements voices were '*I do not know if I am allowed to do that' (Respondent 3); 'I have no idea who to address for that' (Respondent 1).* Which largely corresponds to the complexity of the institutional setting.

### 4.3 The influence of drought experience on the implementation of SWMP

As the above results indicate, drought experience impacts the decision making process in multiple ways. Below, the outcomes of this decision process will be analysed in comparison to drought experience. First, the use of less sustainable water management practices is analysed, thereafter, the general usage of SWMP is analysed, as well as some sub-categories.

#### *4.3.1 The influence of drought experience on water management practices*

Three uses were identified for water management practices, related to their sustainability. The most unsustainable option is diesel sprinkler irrigation that pumps from wells, then there is diesel sprinkler irrigation that pumps from ditches, and, most sustainable, electric irrigation from ditches. There were also some farmers without any kind of sprinklers.

Only two farmers with severe drought experience do not irrigate. One sold his installation 20 years ago, since he found it a hassle and expensive. He now sees the advantage again in having one, but he is expecting to stop farming within the coming two years and finds the benefits not worth the hassle. The other farmer did not irrigate even though he had an installation available. He also named expenses as the main reason not to irrigate. He would have done so in other years, but due to the exceptional high diesel prices, he refrained from irrigating this year. In fact, all farmers that irrigated from wells named the high diesel-price as one of the main disadvantages of diesel-irrigating. Another often stated disadvantage is the hassle it brings along. The following statement captures well how much work and displeasure irrigation does bring.

> *I do not enjoy the memory since irrigation is much, much work. At 11 PM I would turn it on, (...). In the morning, before we went milking we had to reposition that thing, which was a lot of work, so I needed to be up by 5 AM. It was really annoying, and then, at the end of the year I would think, 'what did I gain from it?'. Yes, a lot of costs, a lot of work, and yes, 'what did it deliver?'(Respondent 8).*

Though those that do irrigate share this feeling, they still think it the benefits outweigh the costs. They state different reasons, all related to protecting yield and reducing harm '*for maize it is necessary, it does not grow otherwise, no cob or no nothing, so we irrigate' (Respondent 9)*; '*if you irrigate, you keep it green, it does not grow, but it stays alive'(Respondent 7)*, and '*Feed prices were sky-high as well, so, (...) especially when you count that you do not have to re-sow the grass, I think it outweighs, yes' (Respondent 2).*

In buying a sprinkler installation, frequency seems to matter more than severity. Halve of those with insignificant experience do irrigate. The other halve did not have a sprinkler installation, and it makes no sense to them to invest in one when they always produce enough roughage. Also during dryer years. One of the two farmers that have insignificant, but frequent experience did buy the installation after the two droughts of 2018 and 2019, to be able to irrigate in the summer of 2020. For those that do not irrigate, or bought a sprinkler irrigation, frequency also seems an important consideration to determine the investment of an installation: '*if we have a dry year yet again, and we have feed-shortage, then yes, there will come a sprinkler-irrigation' (Respondent 12).* As this quote mentions, for farmers without irrigation and with no to low SWMP implementation, irrigation is the first adaptation measure that comes to mind.

Interestingly, those who irrigate see the harm they are doing to the groundwater level, especially when multiple neighbours are also irrigating. However, for them, irrigating is a necessity to 'save' their crop yield. Therefore, they still use a sprinkler installation: *Everybody was irrigating. They came every week, and they were irrigating over there, and there was irrigation everywhere. That causes the groundwater level to quicky deteriorate. It went down fast. We, as farmers do contribute to that, yes. (...) I have to save my crop. That is how it works (Respondent 3).* Counter-intuitively, the displacement schedule of the water authority seems to enhance this practice to more unsustainable levels:

> *And that was mainly because I was a bit scared by the prospect of the irrigation ban. It was not here yet, but it was in areas close by. So, I said 'watch out guys, that will come here too, we have to irrigate that maize now, full speed'. Because earlier, I would turn the irrigation system off at night and start it in the morning. But when I heard that, I thought to myself, 'you have to make sure to keep that installation at full speed' (Respondent 3).*

Many farmers investigated if electric irrigation would be a better option for them, especially since the diesel prices were high last year. However, for many, this is not possible due to technical limitations of the electric installation (e.g., distance, easy breakage), or location limitations (e.g., large plots). These reasons hinder farmers from switching to the more sustainable, electric option. However, aside of irrigation, there are SWMPs available to farmers, which they have implemented in various degrees and with differing results.

### *4.3.2 The influence of drought experience on SWMP*

*Types of SWMPs in use*

From the literature review, multiple SWMPs that farmers could implement were identified. Table 4.9, it is indicated how often each type of SWMP is implemented by the farmers, and the drought experience of the farmers using that type of SWMP. "0/6" means that none of the six farmers with that type of drought experience has implemented that measure.

Table 4.9 – SWMP practices that farmers use and their drought experience

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **Targeted irrigation systems** | 0/6 | 0/1 | 0/2 | 0/3 |
| **Rainwater storage** | 0/6 | 0/1 | 0/2 | 0/3 |
| **Diverse water sources** | 1/6 | 0/1 | 0/2 | 0/3 |
| **Soil moisture management** | 6/6 | 1/1 | 1/2 | 1/3 |
| **Crop choices – Singular** | 5/6 | 0/1 | 1/2 | 2/3 |
| **Crop choices – Multiple** | 3/6 | 0/1 | 0/2 | 0/3 |
| **Seasonal water storage** | 1/6 | 0/1 | 0/2 | 0/3 |
| **Longer retainment of water** | 1/6 | 0/1 | 0/2 | 0/3 |
| **Changes in farm management: water saving** | 4/6 | 0/1 | 1/2 | 0/3 |
| **Changes in farm management: cows indoors** | 4/6 | 1/1 | 0/2 | 1/3 |

Two observations can be made from Table 4.9. First, many, especially the storage options, are not (often) used. Not even by those farmers with severe or frequent experience. Multiple reasons were given for this. Either, respondents were incapable of retainment of water, '*you see, I have nothing (a ditch), that is the problem' (Respondent 3); 'I closed of the culvert to keep the water level up, and we had enough water. But then those farmers there got in trouble (with high water)(Respondent 7);* were unaware of the possibilities, even after specific questions aimed at (seasonal) water-storage; or found it too expensive to invest in when there were other options (e.g., irrigation from groundwater and targeted irrigation systems) available, as becomes clear from this statement:

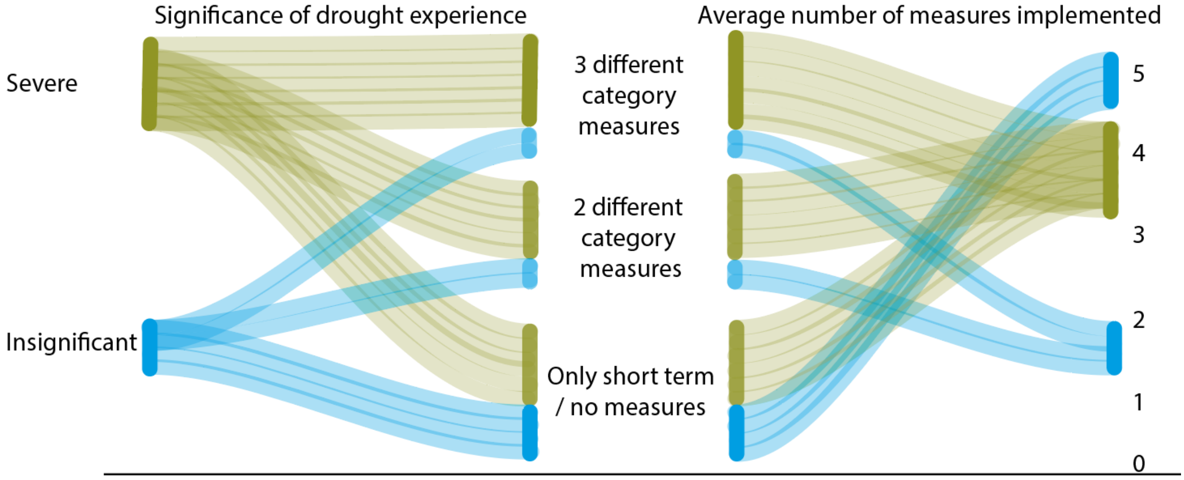
> *Of course there is something to gain with that (water storage), in the future. But for now, I do not think so, you see, I can still always irrigate, I have wells everywhere, I can always access water from there, so why would I invest god knows how much thousands of euros in water storage? (Respondent 3)*

Secondly, the measures are broadly used among different drought experience categories, aside from opting for multiple drought-resilient crop types. However, those with Insignificant, Infrequent Drought Experience kept their cows indoors not because of the drought, but because of the heat, to support animal welfare. Furthermore, soil management and grass-clover mixes do more than just improving drought resilience. Respectively they prevent nitrogen from leaking to the groundwater and store nitrogen from the air. As noted in section 4.2, the Netherlands is currently facing a nitrogen crisis. The government their policy for reducing nitrogen emissions has caused much unrest among livestock farmers, as they are obliged to reduce their nitrogen emissions up to 95% (NOS, 2022a). If they do not reach this within a few years, obliged buy-outs might be a possibility. Therefore, it makes sense that farmers invest in options that reduce their nitrogen-levels, and the effects on drought resilience is not the primary reason to invest for those farmers. Indeed, this view is shared by the ZON expert: "*What we then heard back from the LTO is that all kinds of water-quality measures were more popular than water-quantity measures. Also because of the pressure from politics"*. This reason is also named by the farmers: '*if you do not do it, nitrogen just leaks away towards the water' (Respondent 7).* However, many farmers, especially those in with severe, frequent drought experience note the benefits of grass-clover mixes and soil improvement on drought-resilience. '*I sow clover there, and this summer, the grass stopped growing, yet the clover still grew' (Respondent 3).* Nonetheless, even those who saw this resilience enhancing results have doubts in the overall effectiveness of grass-clover mixes. Overall, yield quantity and quality are lower of these plots than normal grassland. The same reasoning holds for drought-resilient maize: '*when you have regular maize, you just have a lot more, be it quality or yield' (Respondent 9).* Besides, as mentioned in relation to the IAC, these crop types also still depend on water. With low drought experience, SWMP options to reduce the impact of droughts are not considered.

*The influence of frequency*

The theoretical framework assumes that with a higher frequency droughts endured, measures taken will become more structural. Figure 4.1 indeed shows that almost all of those with frequent experience implemented multiple structural and semi-structural measures. The overall measures implemented per person is also higher, especially when there is considered that those with (semi-)structural measures but infrequent experience most often took these measures so for other purposes than enhancing drought-resilience.

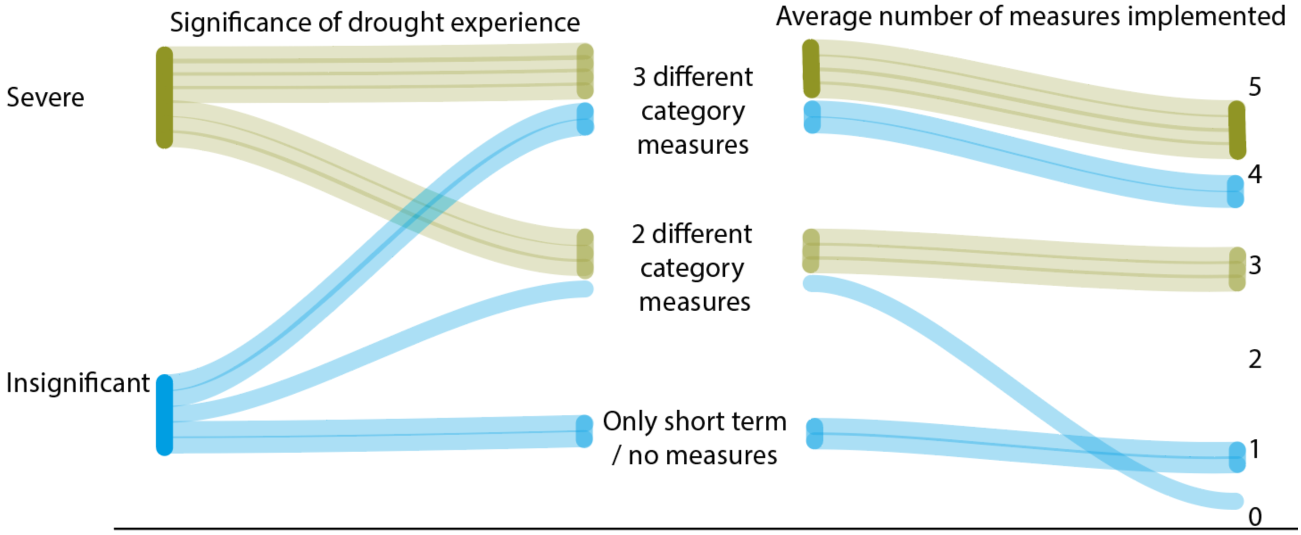
Figure 4.1 – Drought frequency and SWMP implementation



*The influence of severity*

According to the theoretical framework, when the severity of a drought is higher, measures taken will diversify within the different categories, as well as across categories. Figure 4.2 indeed shows that the farmers with more severe drought experience tend to implement more diverse SMWP measures.. Both the numbers of measures per respondent and the number of categories per interviewee is higher. Again, it is especially noteworthy that the only structural measure in place among both respondents with insignificant drought experience is soil improvement. This is to reduce their nitrogen emissions.

Figure 4.2 – Drought severity and SWMP implementation




*SWMP typology*

That drought experience is an indicator for these kind of changes becomes especially clear when the respondents were asked when they took these measures. All farmers with Severe, Frequent Drought Experience opted for these kind of measures (with the exclusion of soil improvement) within the last 5 years. Half of them took these measures after the first or during the second drought, the other half took these measures in one of the latest two droughts. Aside from taking singular measures, the combination of different measures can enhance drought resilience. Table 4.10 shows how drought experience influences the combination of these measures.

Table 4.10 – SWMP typology by drought experience

| | SFDE | SIDE | IFDE | IIDE |
|---|---|---|---|---|
| **Highly enhancing SWMP** | 3 | | 1 | |
| **Mildly enhancing SWMP** | 2 | | | 1 |
| **Slightly enhancing SWMP** | 1 | 1 | | 1 |
| **No implementation of SWMP** | | | 1 | 3 |

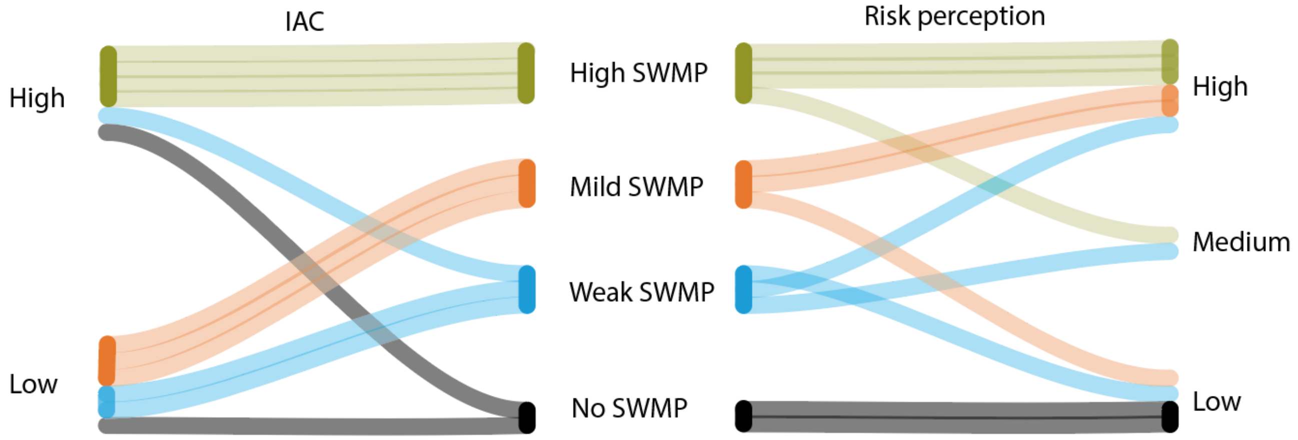
An interesting result in Table 4.10 is the high and mildly enhancing combination of SWMP by those with insignificant experience. For the mildly enhancing SWMP, the farmer has opted for both nitrogen-reducing options, and since soil improvement is structural, and crop choice semi-structural, this farmer falls, unintendedly in the mildly enhancing category. The farmer in the highly enhancing SWMP also ‘accidentally’ found himself in the high category. He applied to be part of the ‘Klimap’ project in 2018. This project focusses on how high sandy grounds can become more climate-resilient through soil and water system adaptations (Klimap, n.d.). Within the scope of this project, he installed groundwater level informed drainage to prevent damage from water surplus. This system also works well to prevent drought damage in a structural way.

Even though those with Severe, Frequent Drought Experience often have taken structural, multiple semi-structural, and short-term measures, none of them feels drought-resilient, as noticed in the risk perception. This implies that changing to other crop types does not reduce the risk during extremely dry years. For that, farmers indicate the need for water. More specifically rainwater, as many note '*you can irrigate, but for yield? You should just irrigate to prevent death of your crops', 'in the end, nothing is better than rain' (Respondent 9)*. This especially holds true for those farmers without a ditch, which severely limits their possibility to store or retain water. Simultaneously, installing basins to store rainwater is not thought of or deemed possible, as explained above.

*Influence of IAC and risk perception on SWMP*

A final assumption made in the theoretical framework was that farmers are more likely to implement multiple (semi)-structural SWMP if they have high IAC and risk perception. Risk perception would be the 'driving' factor of implementation, low risk perception would indicate more short term, singular measures. This relation is displayed in Figure 4.3.

Figure 4.3 – Relationship of IAC and risk perception with SWMP




Two respondents stand out in Figure 4.3. The first has high risk but weak SWMP. This respondent is limited in the measures available to him through policy of the dairy factory. This hinders the farmer from using drought-resilient crop types, no matter the respondents' wishes. This also explains the low IAC of this respondent. The second respondent has low IAC and risk perception, yet has multiple (semi-)structural measures in place. As explained earlier, this respondent took measures against risk of water surplus, which also improved his drought resilience. Aside from these two respondents, there is a clear pattern visible in the combination of IAC and risk perception, and the SWMP implemented by the respondents. As expected, medium or high-risk perception is needed for the farmers to implement at least one (semi-) structural measure. When this is combined with also a high IAC, the farmers have implemented high SWMP.

## 5. Discussion

This thesis aimed to uncover the relationship between drought experience and implementation of SWMP by dairy farmers. In this chapter, the results presented in chapter 4 are compared to the theoretical assumptions and findings from previous studies. Furthermore, the answers to the sub-questions are presented as well as their implications.

### 5.1 The influence of different actors and policies

Sub-question 1 is about the institutional setting in which farmers operate, as this setting largely determines what measures are available to farmers. In the theoretical framework, it was stated that this setting can be found as hindering or supporting drought adaptation. Vermunt et al. (2022) noted three ways in which the Dutch institutional setting hinders mainstream adoption of sustainable agricultural practices that can enhance the resilience of farming systems: nature-inclusive farming lacks financial incentives; farmers hold of sustainable investments since they lack perspective; and finally, compartmentalisation of agricultural policy hinders knowledge sharing and creates regime resistance.

The document analysis showed that this indeed is a complex and multi-actor setting, where knowledge sharing is the responsibility of many different, and often private partners. Farmer interviews showed the lack of knowledge of subsidies among many farmers, and those who had knowledge have so through the right institutions (e.g., LTO, or by having an ancillary function). This view is shared by the ZON expert, who indicated that sharing knowledge about both the subsidies in place, and drought-adaptation measures had been entrusted to the LTO. This also complies with Pearson and Dare (2021), who stated that farmers with more knowledge of the institutional structure implemented more transformative measures than farmers without this knowledge. Indeed, farmers with insignificant drought experience, and with more knowledge of this structure implement mildly to highly enhancing SWMPs, irrespective of the frequency of drought. They felt the institutional setting of both the water authority and the government to be supporting. However, for farmers in both severe, drought experience categories, and less of an 'institutional network', the institutional setting was felt as hindering. This feeling is especially enlarged in places where the water authority struggles with water supply. Regime resistance is felt by most farmers, but this resistance mainly originates from the policy on the nitrogen-crisis.

Interviews also support the proposition that large investments in sustainability practices are put off due to a lack of clear perspective. Famers without succession are not in favour of new investments for the final few years of their work. Also, those that indicated a clear wish to continue wanted to wait till there was more future prospects related to the nitrogen crisis. However, most important for the farmers was that nature-inclusive, or sustainable farming is not as rewarding as the way they are currently running their business. Especially structural measures (e.g., the construction of a water basin) are very expensive without offering any real compensation in return. This complex setting leads to conflict between different water-users. As the most direct competitor for water in some areas, the drinking water supplier was named as a reason for drought damage in the areas affected by the supplier. Currently there are initiatives by farmers to receive higher compensation, as they feel this is lacking. In the areas affected by this water subtraction, the farmers explained that this affected how they felt about their own irrigation practices, which they deemed less harming than the practices of the drinking water supplier. This reduces the likelihood of these farmers changing their irrigation practices.

It can be concluded that the institutional structure that farmers must navigate is dispersed and complex. This complexity is noted by farmers. However, whether or not they find this setting hindering or supportive has mostly to do with their 'institutional network', and the possibilities for water supply (or water abundancy control), at their location. This finding supports the conclusions of Veraard et al., (2016) who stated that reliable freshwater supply and supportive legislation are the most decisive factors in investments in drought measures. Farmers who experience drought are more negative about the institutional setting than those in water abundant regions. Those with drought-experience also find the institutional structure more often hindering their efforts to become more drought-resilient. As the results showed, the combination of a complex, and hindering institutional setting with low freshwater availability does indeed lead to putting of sustainable investments.

### 5.2 The influence of drought on the farmers' decision-making process

*The farmer decision space*

Sub-question 2 is about the influence of drought experience on different factors related to farmers' decision making. As these factors together shape a farmers implementation outcome.In chapter 2, several assumptions were made on how drought experience influences the decision-making process of farmers. The direct influences were assumed to be on factors internal to the farmer, namely, risk perception and internal adaptive capacity. Furthermore, it was assumed an influence of the social setting, which would in turn also impact the farmer-decision space.

The relation between risk perception and drought experience well established in the scientific community (van Tilburg and Hudson, 2022; Keshavarz et Karami, 2016; Grothmann and Patt, 2005). It is assumed that the more severe a previous event has impacted farmers, the higher their risk perception would have been. This relation is supported by the empirical results. Farmers with severe drought experience often felt more at risk than those with insignificant experience. The relationship between the frequency of impact and IAC, as proposed in the framework, is less clear from the interviews. This complies with several previous studies. Habiba et al. (2012) stated that frequency can downplay the IAC of a farmer. Some farmers corresponded with their finding; the IAC, more specifically self-efficacy belief, reduced after multiple droughts, since they discovered that their measures were not sufficient in reducing drought damage. However, other farmers' responses aligned more with the findings of Rey et al. (2017), namely that with a higher frequency of drought, the types of measures implemented would change, which indicates a higher IAC. This was true for some farmers, who had experienced mal-adaptation before. They stated that implementing SWMP took some years to get right. By having multiple droughts, their implementation became more fine-tuned, and they started looking for more measures. Although successiveness of droughts was not mentioned in the literature, this likely is an important dimension of drought experience. A relationship exists between frequency and adaptation intention. Farmers make adaptation investments only after a second successive drought as their necessity to become more drought resilient becomes more prone during the second drought season.

While not assumed in the theoretical framework, there seems to be a link between drought experience and belief in climate change, namely that a higher frequency of droughts reduces doubt in climate change. The necessity to take action for climate adaptation was more felt by farmers that experienced more frequent droughts. These farmers relate to the past as well, stating that their drought experience used to be less frequent, and less severe. Their recent experiences increased their awareness about climate change and the possibility of future droughts. This finding largely corelates to that of van Tilburg and Hudson (2022), who found that awareness, exposure, and risk perception contribute to adaptation support by Dutch farmers. They found that personal impact increased risk perception and that adaptation has happened mainly after 2018. This thesis suggests that experience, through enhancing risk perception and its influence on IAC, leads to drought-adaptation among farmers.

*Farm level and societal factors*

Another, not assumed influence of drought experience was on the external adaptive capacity. This relationship displays a similar dispersed outcome for those with severe, frequent experience, but otherwise this relation is reversed to that of drought experience on IAC. Those with insignificant, drought experiences have a low external adaptive capacity, as they have little knowledge on subsidies and measures they could use. This has to do with their often low risk perception. They do not see the need of investing time in researching what options are available in becoming more drought-resilient, as they see no need in adaptation to begin with. However, those with severe, frequent experience have different external capacities. This has mainly to do with former adaptation attempts. Some farmers view that no measures will be effective (as explained in IAC), and therefore see no ‘new’ measures they can take, furthermore, knowledge of subsidies is limited, or the subsidies are thought to be too low or too difficult to achieve. For farmers with higher external adaptive capacity, they still see possibilities to enhance their drought-resilience by some degree over what they already have in place. They are also aware of subsidies and see fewer complaints in using them. It therefore seems that frequency is influential in seeking knowledge related to drought adaptation, but that the results of former adaptation are determinant in the resulting external adaptive capacity. This result is interesting as it was deemed that external adaptive capacity is a factor that influences at farm level, instead of on farmer level. It seems that for external adaptive capacity, it can be differentiated by having the means that a farmer cannot achieve easily (e.g., more financial capacity or market position) and those that farmers can achieve more easily if they think it is needed (e.g., knowledge of subsidies and measures). This latter is then likely to be affected by the need a farmer feels to adapt.

This study did not yield trustworthy results on the relationship between networks and IAC or risk perception of individual farmers. However, it showed a relationship between networks and external adaptive capacity in sharing knowledge. Especially networks outside of the farming community seem relevant in in distributing knowledge on governmental subsidies. It was shown that social discourse was not perceived as a notable pressure towards more sustainable water management by farmers.

Drought experience thus impacts the farmers’ decision-making process in multiple ways. With a higher frequency of droughts, both the risk perception and the belief in climate change are enhanced. Significance of impact impacts both IAC and external adaptive capacity in a dispersed way when significance and frequency are high. The intervening factor here seems to be former (mal)adaptation, which largely determines the deemed effectiveness of possible new measures taken. Significance also impacts how the water authority is perceived, especially if the agroecosystem limits possibilities that both the water authority and farmers have in reducing drought damage.

**5.3 The influence of drought experience in the implementation of SWMP**

Sub-question 3 is about the relationship between drought experience and the implementation of SMWP by a farmer. In chapter 2, multiple assumptions were made about the relationship between drought experience and the implementation of SWMPs. Keshavarz et Karami (2013) noted that when farmers experience drought more frequently, SWMPs implemented would change from short term to more structural, a finding shared by Rey et al. (2017). Indeed, from the interviews it became clear that when farmers had endured more frequent droughts, they more often installed (semi)-structural measures then when they had experienced droughts only up to two times. For severity, it was assumed that when the severity of impact is high, this will result in a higher diversity of measures implemented. Severity has two indicators, namely loss of agricultural yield and profit, and duration of the drought. The latter was not named by any farmer as a factor increasing the impact within one growing-season. However, when there is a multi-year drought, the implementation of (S)WMP increases. Moreover, from the interviews it did become clear that when farmers experienced a more severe drought, they more often diversified their SWMPs both within and across the different SWMP categories. When frequency and severity are combined, a pattern of changes in SWMP implementation is visible. Farmers with more drought experience implemented a higher resilience-enhancing level of SWMP. An important factor is that farmers with lesser experience sometimes implement (semi)-structural SWMP to comply with governmental ruling to reduce nitrogen-emissions. Therefore, for some measures, drought experience is less of a necessity for implementation. However, regarding enhancing drought resilience, sprinkler irrigation is the first adaptation measure considered; SWMPs only aimed at reducing drought impact are not under consideration.

Drought resilience enhancing options are still available to all farmers. However, there seems to be knowledge on the implementation of water storage within their own property, or a lack of financial capital or subsidies to invest in such measures. Aside of water storage, farmers with significant drought experience often invest in the ‘cheaper’ semi-structural measures of crop choice and structural soil improvement. An often heard argument is that they can buy more feed, or irrigate more before the costs of such expensive measures will be covered. Especially since droughts are not a certainty, most farmers doubt whether it will be economically feasible to invest in. Regardless of this higher SWMP implementation by farmers with both types of significant drought experience, the unsustainability of their water management practices does stay high with these farmers. A commonly shared opinion is that no matter how well many SWMP’s are implemented, supplementing water artificially is a necessity during severe droughts. In the choice where and how to irrigate, practical concerns are driving the choice between electric and diesel, and between wells and ditches.

### 5.4 Implications of the answers to the sub-questions

This thesis shows that the institutional setting hinders drought adaptation amongst dairy farmers in multiple ways. First, through the complexity of the water management setting in the Netherlands, and the privatisation of knowledge distribution, there is a lack of knowledge of subsidies among farmers. Second, when subsidies are known, it is felt as if the conditions are unfeasible and that a true transition towards sustainable farming is not awarding enough. By setting many requirements, farmers feel discouraged to invest in sustainable practices. Third, the national government, especially the parliament, has had a big impact on the drought adaptation process. Through the uncertainty created with the nitrogen policy, many farmers are postponing larger investment in drought adaptation. They indicate that they first must know the viability of their farm in that location, and the investments that would be necessary to make to be able to continue farming under this policy, before they can invest in drought adaptation. Furthermore, with the available subsidies, there are also measures that reduce nitrogen emissions and improve water quality. When farmers are aware of the subsidies, they opt more often for such measures, than measures related to water quantity. A final implication is that water availability and drought damage reduction by the water authority seem to be related to the perception of farmers towards the water authority. This could imply that when droughts occur more broadly and often in the future, the support base for the water authority will reduce.

This thesis furthermore showed that the frequency of droughts endured affects both internal, and external adaptive capacity, with (mal)adaptation as an intervening factor. This implies that farmers face unnecessary damage by adapting too late, as it was shown that larger investments are considered only after multiple years of financial losses. Furthermore, those with insignificant experience have a lower risk perception, and those with high risk perception only have so since they experienced severe and reoccurring droughts since 2018. This implies that in campaigns raising awareness of drought risk, playing on affective emotions will do more than showing factual numbers. It furthermore means that such campaigns are necessary to create drought risk awareness among farmers. Since those without drought experience do also not expect this in the future, and thus do not prepare for such events. The necessity of creating awareness and distributing knowledge is especially true since adaptation is a multi-year process, where the permanence of SWMP changes when more frequent droughts are endured. But it was also voiced that adaptation is difficult and that measures take multiple years to get right. This indicates a knowledge gap of hands-on experience in implementing the known measures.

This thesis explored the relationship between drought experience and SWMP implementation among mid-sized dairy farmers in Salland. In similar settings, characterised by a viable agricultural sector and within a highly-regulated institutional context, the same factors likely apply to dairy farmers in regions with no historic drought experience. However, as this thesis is one of the first to study farmers’ decision making within such a context, factors identified in the theoretical chapter were identified in settings with small-holder farms and without a highly-regulated institutional setting (e.g., Habiba et al., 2012; Keshavarz et Karami, 2016; Ghanian et al., 2020). Often, these studies were in countries with a long history of droughts. Yet, the same factors proved to be influencing in a similar matter in this new context. The findings therefore add to the transferability and strength of this and the frameworks developed by researchers.

# 6. Conclusions

In this chapter, the main research question: *How does experience with drought influence the implementation of sustainable water management into agricultural practices among dairy farmers in Salland?* is answered by combining the results of the three sub questions. Thereafter, limitations of this thesis and possible future research are discussed.

The impact of drought experience on the implementation of SWMP is twofold. First, there is a link between drought experience and different farmers' decision-making factors. These are external adaptive capacity, perception of institutional context, belief in climate change, risk perception, and IAC. These factors then determine the adaptation options and choices of the farmer. However, there is a more direct link between drought experience and the implementation of SWMP. The different aspects of drought experience differently impact the type of SWMP implemented.

It was found that drought experience impacts the perception of the institutional context. With higher impact drought experience, the general feeling towards the water authority became more negative, and measures post by this authority were said to hinder farmers both in increased damage and in adaptation options. Moreover, drought experience in general impacts external adaptive capacity, since those with drought experience actively look for adaptation possibilities, seeking knowledge needed for adaptation. The relationship between drought experience and network was untestable in this thesis.

There are also nuanced impacts of the dimensions of drought experience on the farmers' decision-making factors. Different from the theoretical framework developed in chapter 2, former (mal)-adaptation is included as an intervening factor between frequency and both external adaptive capacity and IAC as an important determinant of the ability to see new possibilities and their perceived effectiveness. A higher frequency of droughts furthermore leads to less doubt in climate change while more severe impact increases risk perception. Also different from the theoretical framework developed in chapter 2 is the inclusion of '*duration of droughts'*, as a dimension of drought experience, and its relationship with internal adaptive capacity, especially adaptation intention.

Apart from the impact of drought experience on the different farmers' decision-making factors, a relationship between drought experience and the SWMPs implemented were found. In general, the type of drought experience influences the outcome. Less severe and infrequent drought experience led to farmers with no or low levels of drought adaptation, and where they adapted this would more often lead to short term measures or water management practices. Whereas more severe and more frequent experiences led to higher levels of drought adaptation. Yet, none of the farmers quite reached full drought resilience, since water storage in basins is not considered for practical or monetary reasons. Furthermore, farmers with less severe and infrequent experiences had installed some (semi-)structural practices, but did so unintendedly, as these measures were in the first place installed to reduce their nitrogen emissions. Aside of this 'general' impact, there were relationships between the dimensions of drought experience and the type of SWMP implemented by the farmers. When farmers endured more droughts, the permanency of their measures increased, these measures went from short term to (semi-)structural. Both severity and duration of the droughts endured impact the number of measures taken, as well as an increase in the variety of the permanency of these measures.

It can thus be stated that the relationship between drought experience and the implementation of SWMP is multitude and complex, but that it does influence both the amount and type of SWMPs implemented by a farmer. This relation can be further explained by looking at how drought experience impacts upon the different factors of farmers' decision-making, that determine which options a farmer has, and how he perceives his adaptation options.

## 6.2 Limitations of the research

This thesis has a few limitations. It was a small-n, qualitative study, and therefore, the conclusions cannot be generalised or extrapolated into another context or to a larger scale. Another problem was that due to the resistance of most farmers to commit to the study, the original inclusion criteria of farmer size was not met by all respondents. Two farmers had extensive farms with fewer than 50 cows. In the data analysis, these two cases were part of the overall pattern, however, due to the sample size, it cannot be ruled out that this still influenced the result of the analysis. The expert interviews did yield some interesting results, however, by speaking to only one expert from each organisation, their statements hold little validity. Possible personal biases from the experts therefore could not be identified. However, the function of these experts within their organisations (board member of the WDOD, policy maker on rural areas and water with the province) do indicate their relation to the topic of drought and their knowledge of this. Despite these limitations, the thesis provides valuable information on climate change adaptation behaviour amongst dairy farmers in Salland, and indicated some strong relationships between the identified factors and SWMP implementation.

Another limitation was that 5 of the 12 respondents indicated to stop farming in the (near) future, without having succession for the company. Some of these farmers actively stated this as a reason to lay off investments, with other farmers this was not actively discussed, but a similar effect is possible. For further research, it would therefore be recommended to use this as an exclusion criterion for respondents. By only researching those farmers that continue with their farm, relations likely will become more clear.

The final limitation is regarding the nitrogen crisis, which was an urgent issue in the Netherlands at the time of the study. Due to this crisis, farmers indicated that they postponed vast investments. Since this crisis has been developing since 2019, the second year of drought, it has likely impacted the implementation of SWMP during the drought years that followed. It is possible that without this crisis, the level of drought resilience would have already been higher in those farmers with in both categories of severe drought experience. This shows that prioritization of transition pathways should have been included in the theoretical framework, to better predict implementation.

### 6.3 Future research directions

Future research directions can be identified to build on the results of this thesis. First, the dispersed relationships between drought experience and both internal and external adaptive capacity are worth studying in a large-n quantitative setting. This would allow to test if (mal)adaptation indeed is the most important intervening variable in this relation. Second, few studies have quantitatively tested the relation between drought experience and SWMP implementation. Quantitatively testing the frequent implied relation in qualitative studies can test if the relationship proposed is applicable to other regions and countries. Making it possible to base (inter)national policies on the results, which can aid in developing more effective policies.

A third research direction stems from the conclusion that none of the farmers have made significant investments in drought resilience measures. Possibly, this is because currently, farmers had at most faced drought four times in the last five years. Before that, droughts were rare. Perhaps, if droughts persist, it may become the norm, resulting in greater investments in structural measures. It would be interesting to re-do this study in a few years, granted there were more droughts, and see whether more investments have been made in truly structural measures.

Fourth, this thesis showed that external adaptive capacity likely can be divided between hard to change dimensions (e.g., financial capacity) and easily changed dimensions (e.g., knowledge). Further research could focus on this difference and see just how these factors interrelate to provide better understanding of when farmers seek out the knowledge needed to be able to become more drought resilient.

Fifth, This thesis showed that farmers prioritize between transition pathways, future research could focus on implementing such prioritization in the theoretical framework and test how this prioritization happens. Finally, the results of the negative stance towards the water authority are also worth investigating, as it could lead to regime resistance and hinder adaptation efforts.

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## Appendix A – SWMP Measures and Categories

| Measure | Long/Short term | Stage DRM | Reference |
|---|---|---|---|
| Irrigation<br>- Optimising water delivery systems (reducing leakages)<br>- Adjustable, level-controlled or underwater drainage.<br>- Targeted watering systems (e.g., drip irrigation, nano technology).<br>- Selective irrigation | <br>Long term<br>Long term<br>Long term<br><br>Short term | <br>Prevention<br>Response<br>Prevention<br><br>Response | OECD, 2010; LTO, 2013; Van Duinen et al., 2014; Rey et al., 2017; Holman et al., 2021; Hanger-Kopp and Palka, 2021; Keshavarz and Karami, 2013 |
| Water storage<br>- Stores rainwater in a basin, pond weir or lake,<br>- Makes agricultural land available for extra-legal water storage on land.<br>- Drilling/deepening wells, constructing reservoirs | Long term | Preparation | OECD, 2010; LTO, 2013; Van Duinen et al., 2014; Keshavarz and Karami, 2013; Hanger-Kopp and Palka, 2021; Habiba et al., 2012 |
| Type of water used<br>- Greater use recycled sewage and drainage water and desalinated water (from 3rd parties)<br>- Investment alternative water sources<br><br>- Purchasing extra water | <br>Long term<br><br>Long term<br><br>Short term | <br>Prevention / response<br>Prevention/ response<br>Prevention Response | OECD, 2010; LTO, 2013; Rey et al., 2017; Keshavarz and Karami, 2013; Van Duinen et al., 2014; Habiba et al., 2012 |
| Soil moisture management<br>- Depth ditch in peatland areas (at least 30 cm deep).<br>- Organic soil building techniques,<br>- Agronomic management (manure & composting, seedbed method)<br>- Conservation tillage | Long term | Prevention | OECD, 2010; LTO, 2013; Knutson et al., 2011; Holman et al., 2021; Habiba et al., 2012; Hanger-Kopp and Palka, 2021 |
| Crop choices<br>- Adoption of drought-resistant cultivars<br>- Avoiding a second crop<br>- Crop intensification (diversified crops, cropping pattern) | <br>Long term<br>Short term<br>Long term | <br>Prevention<br>Response<br>Prevention | OECD, 2010; Van Duinen et al., 2014; Rey et al., 2017; Knutson et al., 2011; Holman et al., 2021; Hanger-Kopp and Palka, 2021; Keshavarz and Karami, 2013; Habiba et al., 2012 |
| Seasonal water demand<br>- Recharging groundwater during times of low seasonal water demand<br>- Artificial infiltration when there is a surplus of fresh water to supplement the fresh water supply.<br>- Water-level-regulated drainage. Water level in drains is actively increased in summer enlarging the freshwater lens<br>- Decrease water level in ditches. Water levels in ditches are actively decreased in winter preventing freshwater drainage | Long term | Preparation | OECD, 2010; LTO, 2013; Van Duinen et al., 2014 |
| Longer retainment<br>- Increases drainage base in watercourses to retain water longer in free-flowing areas.<br>- Minimise runoff by constructing infiltration trenches, sills and by roughening ridges.<br>- Increasing depth/spread drains expands the freshwater lens | Long term | Preparation/ Prevention | LTO, 2013; Van Duinen et al., 2014 |
| Farm management<br>- Develop water management plan<br>- Investment in water supply<br>- Other income generating activities | Long term | Prevention | Rey et al., 2017; Holman et al., 2021; Habiba et al., 2012 |

## Appendix B – Factors of Farmer Decision-making under Drought Experience

Table B1**.** Economic Factors

| **Economic indicators** | **References** |
|---|---|
| Economic disincentives | Ghanian et al., 2020; Holman et al., 2021 (capital investment, operational, profits foregone, lost opportunity) |
| Historical experience/ | Keshvarz et al., 2013; Ghanian et al., 2020; Sharma and Patt, 2011 |
| Farm location | Khanian et al., 2017; Guo et al., 2022 |
| Accurate understanding of threat | Grothmann and Patt, 2005; Ghanian et al., 2020 |
| Response efficacy | Grothmann and Patt, 2005; Keshavarz and Karami, 2016 |
| Response costs | Grothmann and Patt, 2005; Ghanian et al., 2020; Knutson et al., 2011; Shiferaw et al., 2009; Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Income | Keshavarz and Karami (2016); Guo et al., 2022; Liu et al., 2019; Shiferaw et al., 2009; Keshavarz and Karami, 2016 |
| Adaptation incentives | Grothmann and Patt (2005); Ghanian et al., 2020; Shiferaw et al., 2009 |
| Level of education | Daberkow and Mcbride; Liu et al., 2019 |
| Objective adaptive capacity (power, money, entitlements, knowledge) | Grothmann and Patt (2005); Guo et al., 2022; Knutson et al., 2011 (drought planning knowledge); Özerol and Bressers, 2017; Bagagnan et al., 2019 (knowledge); Röling, 2003 (knowing) |
| Ecological factors | Guo et al., 2022 |
| Resources | Guo et al., 2022; Özerol and Bressers, 2017; Grothmann and Patt, 2005; Keshavarz and Karami, 2013 |
| Production costs | Guo et al., 2022; Liu et al., 2019 |
| Family characteristics | Guo et al., 2022 |
| Direct drought impact experience | Habiba et al., 2012; Sharma and Patt, 2011; Bagagnan et al., 2019; Grothmann and Patt (2005); Rey et al., 2017 |
| Soil condition / water availability at location | Hanger-Kopp and Palka, 2021; Holman et al., 2021; Özerol and Bressers, 2017 |
| Weather / climate at location | Hanger-Kopp and Palka, 2021; Holman et al., 2021 |
| Farm structure and operations | Hanger-Kopp and Palka, 2021; Holman et al., 2021; Liu et al., 2019; Shiferaw et al., 2009 |
| Government regulations, subsidies and payments | Hanger-Kopp and Palka, 2021; Liu et al., 2019; Özerol and Bressers, 2017; Röling, 2003; Shiferaw et al., 2009; Grothmann and Patt, 2005 (barriers) |
| Market prices and command | Hanger-Kopp and Palka, 2021; Holman et al., 2021; Knutson et al., 2011 (need to maximize production); Shiferaw et al., 2009 |
| (Un)reliability of forecast | Knutson et al., 2011 |
| Crop profiles | Liu et al., 2019 |
| Knowledge of institutional structures and policies | Pearson and Dare, 2021 |
| Agroecosystem | Özerol and Bressers, 2017; Shiferaw et al., 2009 |
| Recent personal experience | Sharma and Patt, 2011; Weber, 2006; Grothmann and Patt, 2005 |
| Frequent exposure | Weber, 2006; Habiba; Sharma and Patt, 2011; Keshavarz and Karami, 2013 (stage of drouhgt); Rey et al., 2017 |
| Extrinsic reward | Bagagnan et al., 2019 |
| Farm Size | Keshavarz et al., 2010 |

Table B2. Psychological Factors

| **Psychological indicators** | **References** |
|---|---|
| Adaptation intention | Ghanian et al., 2020; Bagagnan et al., 2019; Grothmann and Patt (2005) |
| Former maladaptation | Ghanian et al., 2020 |
| Belief in climate change | Ghanian et al., 2020; Habiba et al., 2012; Özerol and Bressers, 2017; Bagagnan et al., 2019; Grothmann and Patt (2005) |
| Risk perception | Ghanian et al., 2020; Habiba et al., 2012; Röling, 2003; Grothmann and Patt (2005); Rey et al., 2017 |
| Perceived adaptation success | Ghanian et al., 2020; Holman et al., 2021; Knutson et al., 2011; Röling, 2003; Grothmann and Patt (2005) |
| Perceived vulnerability | Grothmann and Patt, 2005; Sharma and Patt, 2011; Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Perceived severity | Grothmann and Patt, 2005; Özerol and Bressers, 2017; Sharma and Patt, 2011; Bagagnan et al., 2019; Keshavarz and Karami, 2016; |
| Self-efficacy | Grothmann and Patt, 2005; Ghanian et al., 2020; Knutson et al., 2011; Röling, 2003; Bressers et al., 2016; Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Risk awareness | Habiba et al., 2012; Sharma and Patt, 2011; Rey et al., 2017 |
| Personal views and beliefs | Liu et al., 2019; Özerol and Bressers, 2017; Röling, 2003 |
| Feeling of ownership over the problem | Özerol and Bressers, 2017 |
| Outward orientation / innovative | Pearson and Dare, 2021 |
| Affective emotions | Peters and Slovic, 2000 |
| Values, emotions, goals, purposes, wants | Özerol and Bressers, 2017; Röling, 2003; Van den berg et al., 2000 |
| Internal goals and values | Bressers et al., 2016 |
| Feeling of alarm | Weber, 2006 |
| Threat appraisal | Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Coping appraisal | Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Response efficacy | Bagagnan et al., 2019; Keshavarz and Karami, 2016 |
| Intrinsic reward | Bagagnan et al., 2019 |
| Willingness to continue farm | Keshavarz and Karami, 2013 |

Table B3. Social and Institutional Factors

| **Social indicators** | **References** |
|---|---|
| Social environment and discourse on climate adaptation. | Keshavarz and Karami (2016); Grothmann and Patt (2005); Knutson et al., 2011; Shiferaw et al., 2009; Keshavarz and Karami, 2016 |
| Personal network and relations to others that implement SWMP or hold knowledge on drought (solutions) | Grothmann and Patt ,2005; Keshavarz and Karami, 2016; Knutson et al., 2011; Özerol and Bressers, 2017; Pearson and Dare, 2021; Shiferaw et al., 2009; Van Duinen et al., 2012. |
| **Institutional setting** | **References** |
| structure, laws and policies in place | Grothmann and Patt, 2005; Hanger-Kopp and Palka, 2021; Holman et al., 2021; Keshavarz and Karami, 2016; Knutson et al., 2011; Liu et al., 2019; Özerol and Bressers, 2017; Pearson and Dare, 2021; Röling, 2003; Shiferaw et al., 2009; Vermunt et al., 2022. |

# Appendix C – Interview Guide

## Guide for Interviews with Farmers

Niet antwoord plichtig
Toestemming opname?
Waarom dit onderzoek: eigen ervaring; overheid helpen agrarische sector te helpen
Hebben over klimaat, water beheer, en maatschappij

Droogte: wanneer de bodem te droog is om gewassen of gras te laten groeien of niet te verdorren.
Duurzaam watergebruik: watergebruik aangepast aan de natuurlijke waterbeschikbaarheid.

| | | | |
|---|---|---|---|
| ***Farm type*** | | | |
| a | Number of cows | Hoeveel melkkoeien heeft u? | |
| | | | |
| **How does experience with drought affect the degree of implementation of Sustainable water management practices by dairy farmers in Salland?** | | | |
| ***Experience*** | | | |
| 1 | Personal impact | Hoe heeft de ergste droogte sinds 2018 impact gehad op u en uw bedrijf? | |
| 2 | Duration of drought | Hoe lang hield deze droogte aan? Werd de impact van de droogte erger over tijd? | |
| ***Klimaatverandering*** | | | |
| *3* | Belief in climate change | Hoe denkt u dat klimaatverandering invloed heeft op verleden en toekomstige droogtes? | |
| *4* | Risk perception | Wat voor risico vormt droogte voor uw bedrijf? | |
| 5 | Internal adaptive capacity + external | Welke maatregelen kan u nemen om droogte schade in de toekomst te beperken? | |
| ***Agro-ecosystem*** | | | |
| 6 | Water availability | Hoe is de watervoorziening op uw locatie, in uw ogen, anders dan de rest van Salland? En welke impact heeft deze locatie op de mogelijke keuzes die u heeft voor het nemen van duurzame maatregelen? | |
| ***Degree SWMP implemented*** | | | |
| 7 | (S)WMP? | Welke waterbeheer methoden gebruikt u op het bedrijf? | |
| 8 | SWMP | If none SWMP mentioned ask: | (type gewassen, waterberging, organisch gehalte van aarde) |
| 9 | | Why these? | Heeft u ook andere (duurzame) maatregelen overwogen en wat was uw afweging hierin? |
| 10 | When implemented | Wanneer heeft u deze maatregelen genomen, en waarom toen?, Wat was de invloed van droogte in deze beslissing? | |
| 11 | Hoe heeft u deze maatregelen gefinancierd, en hoe zou u mogelijk nieuwe maatregelen financieren? - subsidies? | | |
| ***Institutional / social setting*** | | | |
| 12 | Hinderance/ supportive | Hoe heeft het overheidsbeleid en de waterschappen impact op de maatregelen die je kan nemen tegen droogte? | |
| 13 | Market | Hebben de marktwaarde en vraag naar producten of marktpositie impact op uw beheer? | |
| 14 | Social discourse CC | Ervaart u druk vanuit de samenleving om te verduurzamen, en wat voor impact heeft dit op uw waterbeleid? | |
| 15 | Network | Praat u wel eens met andere melkveehouders over waterbeheer en droogte? Zo ja, wat voor impact hebben deze gesprekken op uw keuze voor bepaalde activiteiten met watergebruik? | |

Dankuwel voor uw tijd.
Mocht je iets willen veranderen of toevoegen aan deze informatie, of wil je toch niet dat je antwoorden worden mee genomen in het onderzoek, kun je gerust contact opnemen.

## Questions for the expert from the water authority

1. Hoe helpen jullie boeren met het weerbaarder worden tegen droogte?
2. Komen boeren naar jullie toe of benaderen jullie boeren?
3. Welke wet en regelgeving is er vanuit het waterschap / overheid rondom droogte?
4. Heb je het idee dat boeren zich bewust zijn van droogte – risico's
    - En adaptatie mogelijkheden?

5. Welke factoren denk je dat meeweegt in het besluiten van een maatregel?

## Questions for the ZON expert

Maatregelen:

1. Veel boeren geven aan hun bodemstructuur in grasland/akkerbouw te verbeteren. Hiervoor bemesting met oa. Stromest belangrijk. Meer dan kunstmest, hoe heeft de afschaffing derogatie hier impact op?
2. Is druppel-irrigatie mogelijk op maisland? Zo ja, heeft u het idee dat dit gedaan wordt? Waarom niet?
3. Een aantal boeren die ik sprak hebben geen sloot, geen mogelijkheid tot wateraanvoer, welke maatregelen zouden zij kunnen nemen om op een duurzame manier hun gewassen (gras-mais) te telen?

Proces:

4. Werd er veel gebruik gemaakt van subsidiemogelijkheden door Agrariërs?
5. Hoe verliep het contact met Agrariërs?
    a. hoe werden zij geïnformeerd over mogelijke maatregelen?
    b. Hoe werden zij geïnformeerd over de noodzaak tot aanpassing / het effect van beregenen? Zien zij dit zelf ook?
    c. Kwamen agrariërs zelf met kennis vragen over droogte-adaptatie? Wat was de meest gestelde vraag?
6. Kwamen de aanvragen vanuit een specifieke groep Agrariërs? (locatie / grootte)
    a. Zat er verschil in de aanvraag per jaar? (bijvoorbeeld in een droger jaar meer)
    b. Wanneer bedenken ze, nu is het noodzaak voor aanpassing?
        i. Welke rol speelt duurzaamheid in deze keuze?
7. Welke afwegingen maken Agrariërs volgens u bij het nemen van waterbeheer-maatregelen?

8. Ik zag dat deel 1 ondertussen is afgesloten, wat voor impact heeft naar uw inziens deze fase gehad in de weerbaarheid tegen droogte bij agrariërs?
9. Wat waren de belangrijkste conclusies over weerbaarheid en kennis bij agrariërs over droogte?
10. Wat zijn de plannen voor de voortzetting van het project met betrekking tot agrarische bedrijven?

11. Een opvallende conclusie van mijn onderzoek is dat het waterschap (WDOD) zegt zeer bezig te zijn met draagvlak onder agrariërs en dat zij dan ook goed bekend staan. Echter hebben agrariërs in droge gebieden juist geen goede ervaringen met het waterschap. Bent u bekend met dit verschil in perceptie, en welke verklaring zou u hiervoor kunnen bedenken?

# Appendix D – Coding Scheme

## 1. Coding scheme after second round coding

| Code-category | Code | Description |
|---|---|---|
| **Demographics** | | |
| Gender | Male | |
| | Female | |
| Ancillary positions | Agrarian consultant | |
| | Member board WDOD | |
| | Politician | |
| Ownership | Single owner | |
| | Partnership with family | |
| Succession? | Yes | Whether or not a farmer has succession for the farm can be an indicator for his willingness to make large investments |
| | No | |
| **Agroecosystem** | | |
| Number of cows | <50 | Farm size is an indicator for both drought risk and adaptation options. Small farmers have fewer adaptation options |
| | 51-75 | |
| | 76-110 | |
| | 111-135 | |
| | 136< | |
| Soil type | High | Soil type is an indicator for drought risk. High, sandy soils are more at risk of drought damage than low peat soils. |
| | Low | |
| | Sandy | |
| | Peat | |
| Location perception | Does limit drought risk | How farmers perceives the water availability at their location is an indicator for how drought prone that location is. |
| | Neutral | |
| | Enhances drought risk | |
| Farm type | Extensive | Intensive farms will more quickly experience a drought as severe |
| | Intensive | |
| Water availability | Close by river or ditch available | The easiness with which farmers can access water is both an indicator for drought risk, as well as for SWMP and irrigation options. |
| | No ditch available | |
| | Ground water level almost always sufficient | |
| | Low ground water level low | |
| **General (water) adaptation statements** | | |
| | Conscious adaptation (sustainable/organic) | General statements and feeling about climate adaptation can indicate how 'willing' or aware a farmer is to adapt in a sustainable way |
| | organic/sustainable not possible - location constraints | |
| | considerations due to sustainability | |
| | Considerations due to costs | |
| **Decision space – Belief in climate change** | | |
| Belief in climate change | Strong belief | How a farmer is perceiving climate change is an indicator for how much need he sees to change. |
| | Doubting | |
| | No belief | |
| **Decision space – Internal adaptive capacity** | | |
| Plans to continue under drought | Doubt if possible under drought | If there is doubt that continuing under drought is possible, the farmer is less likely to adapt. |
| | Possible under drought | |
| Perception effectiveness | No, against severe droughts no SWMP will help. Only irrigating will help. | If a farmer thinks the possible measures he can take will be effective, he is more likely to take measures in the future. |
| | Damage can be partially prevented | |
| | No, against real drought you cannot even irrigate | |
| | Damage can be prevented entirely | |
| Former adaptation | Previous measures taken successfully | If a farmer has experiences positive results in the past by adapting, he is more likely to try other measures, or repeat earlier semi-structural |
| | Previous measures not successful | |
| | Previous measures partly successful | |

| | | |
|---|---|---|
| | | measures, then when he previously used ineffective measures. |
| No ownership, is up to water authority | | |
| No new investments planned | Not necessary, all is going well | |
| | No, since considering to quit | |
| Innovative | Innovative | If a farmer is innovative, he is more likely to become an early adopter of new SWMP |
| | Not innovative | |
| Plan to quit in future | No succession | If the farmer knows he will stop farming in the near future, the farmer is less likely to adapt through big investments. |
| | Difficult to continue due to regulations | |
| | Difficult to continue under drought | |
| **Decision space – Risk perception** | | |
| Expectation of drought | Expect no future drought damage | If a farmer expects new droughts to cause damage, he will most likely take action to try and reduce the impact. |
| | Expect new drought | |
| | Expects damage in future due to drought | |
| Sees need for adaptation | Consideration of whether to buy in feed or irrigate more | If a farmer expresses the need to adapt, he is most likely making plans to adapt. |
| | Was aware too late that drought affected maize | |
| | Sees no need for adaptation | |
| | Sees need for adaptation | |
| **Drought experience** | | |
| Active memory? | Drought since 2018 | The timing of the drought memory is an indicator for the likelihood of affective feelings |
| | Drought since before 2018 | |
| Frequency | 0 | The number of droughts endured (since 2018). |
| | 1-2 | |
| | 3-4 | |
| Financial losses | Expenses on expensive diesel for irrigation | The damages to the farm which required the farmer to either give up incomes or to spent more as a result of drought. High expenses likely result in a feeling of need to adapt to prevent future, similar expenses. |
| | Grass restoration costs | |
| | Could not rent out the land | |
| | More pesticide needed | |
| | Necessary to buy feed | |
| | Feed was more expensive due to drought | |
| Damage prevention | Only partial crop damage through irrigation | The prevention of more severe damages through making extra investments. Although damages, these are less significant than Financial or crop losses. |
| | No damage through irrigation | |
| | Not having to buy feed through stock drawdown. | |
| Advantages of drought | No damage at all | No losses without taking action is likely to result in low adaptation intention, as is having benefited from drought. |
| | Longer growing season compensates | |
| | Less water surplus damage | |
| Crop damages | Dead grass | The damages to the farm which resulted in lower yields or led to increased costs to 'safe' the crops. Higher damages likely result in a feeling of need to adapt to prevent future, similar damages. |
| | Dead maize | |
| | Lower quality and yield of grass | |
| | Lowe quality and yield of maize | |
| | More pests | |
| | Increased weed pressure | |
| Cows inside because trampling mat, not enough feed | | |
| **External adaptive capacity** | | |
| Capital for investment | Yes | If a farmer has enough capital to invest in measures, he is more likely to do so then when he has to rely on subsidies / go in debt. |
| | No, measures too expensive | |
| Market position | Consumer is not going to pay more for sustainable products | How a farmer perceives his market position is an indication for how |
| | Consumer is already struggling to make ends meet higher priced products | |

| | | |
|---|---|---|
| | Consumer will have to pay, all products are getting more expensive | willing he is to make investments that will result in a higher retail price. |
| | Retail price will rise due to drought damage (measures) | |
| Knowledge Subsidies | Knows tax deduction | The awareness of subsidies is an indication for investment, as subsidies will lower the bar to expenses. |
| | Knows POP3, DAW, ZON or premiums | |
| | Is not aware subsidies | |
| | Finds subsidies too low, the investment too expensive, or too many conditions to meet | |
| Knowledge adaptation opportunities | Yes, other business model | The awareness of (sustainable) adaptation options is an indicator for future adaptation intentions and feeling of effectiveness in taking (more) measures. |
| | Yes, irrigation | |
| | Yes, drip irrigation | |
| | Yes, one / more other crops | |
| | Yes, cows inside (longer) | |
| | Yes, less leasing / more land | |
| | Yes, increase organic matter | |
| | Yes, retain water | |
| | No, no opportunities | |
| **Institutional Context – National and Local Governments** | | |
| Experience and opinion | Focus too much on small issues | A negative feeling towards the government can result in asking for help later, or in working against the government. |
| | Are against farmers and food production | |
| Hinderance | Find policies hindering in drought adaptation (because of contradictions, limitations, or swaying) | If farmers find the policies, and policy approach hindering in their transition towards drought-resilience, this indicates that this context could be improved to ensure a smoother transition.<br>If the government is supporting drought-adaptation, it is likely that measures will be taken more quickly. |
| | Short term vision – no structural adaptation | |
| | Uncertain and swaying policy leads to intensification | |
| | Uncertain and swaying policy leads to postponing investments | |
| Supportive | Expects subsidies for drought-resilience measures | |
| **Institutional Context – Water authority** | | |
| Experience and opinion | Farmers should (be able to) cooperate with water board | A negative feeling towards the water authority can result in asking for help later, or in working against the government. |
| | Good experiences with it, both in contact and opportunities | |
| | Is (too) expensive | |
| | Cumbersome, inefficient, does not respond to complaints | |
| | Consultation agenda not possible, do not think along | |
| | Little contact, only for complaints or consultation, must come from the farmer | |
| Hinderance | By waiting for complaints = measures too late | If farmers find the policies, and policy approach hindering in their transition towards drought-resilience, this indicates that this context could be improved to ensure a smoother transition.<br>If the water authority is supporting drought-adaptation, it is likely that measures will be taken more quickly. |
| | Financial damage caused by measures | |
| | Measures worsen issue, measures at wrong time , does not perform tasks or performs tasks incorrectly | |
| | Understands that location limits opportunities | |
| | Expects problems with self-imposed measures | |
| Supportive | Reduced damage because of measures | |
| | Consultation and coordination possible | |
| | Water board the institution for help and knowledge climate adaptation | |
| **Institutional Context - General** | | |
| Lost confidence in LTO | | If farmers experience the institutional in general as hindering their options for drought-adaptation, they are less likely to take action to become more drought resilient. |
| Unsure whom to approach / who responsible | | |
| Dairy factory regulations lead to increased costs and reduced opportunities for adaptation | | |
| Vitens: drought damage compensation does not outweigh costs - wants customisation | | |
| Vitens: big problem, pumps out of area, main reason drought | | |
| **Social context** | | |
| Network | Contact with municipality | |

| | | |
|---|---|---|
| | Contact with province | Having a broad network is likely supporting the farmer with knowledge of subsidies and possible measures. |
| | Some farmer friends and neighbours | |
| | Member of study clubs - workshops | |
| | LTO | |
| | Cooperation with water management network | |
| | Technical advisor | |
| | Conflicting advice | |
| | Little or only superficial contact | |
| Thoughts on social discourse on climate change | Not only agriculture needs to adapt | If the farmer finds the social discourse resulting in a pressure to adapt to become more sustainable, this will likely result in quicker adaptation of SWMP. However, negative feelings over society will likely reduce this felt pressure to change. |
| | Consumers do not realise what farmers are already doing | |
| | Society says more sustainable | |
| | Find that consumers (or other sectors) also have to become more sustainable themselves | |
| | Society is judgmental | |
| | Does not feel pressure, or does not care, finds pressure exaggerated | |
| | Does not need society to tell him change needed, sees need for adaptation | |
| **SWMP - measures** | | |
| (Level-controlled) drainage | | Structural measure |
| Other crops | Other grass composition - grass-clover | Semi- structural measures |
| | Other grass composition - herbaceous | |
| | Drought-resistant maize | |
| | What is grown where will change | |
| Conscious saving | General saving | Short-term measures |
| | Do not irrigate too much, soil cannot handle it | |
| | Irrigating at night / windless | |
| Soil measures | Fertilisation / compost for organic content | Structural measures |
| | Non-inversion tillage - or not ploughing grassland | |
| Extensive | No additional soil available | Structural measure |
| | Longer lasting under drought, less procurement needed | |
| Cows inside otherwise trample grass and not enough feed | | Short term measure |
| Water storage / retention - and delay | No ditch or drained ditches - very limited possibilities | Semi-structural |
| | Ditch pumped full from well - was disappointing | |
| | Ditches closed (balloon, culverts, dam, sand) | |
| | Ditches kept clean | |
| **SWMP – Disadvantages** | | |
| Reason against other crops | Trade-off too wet - too dry | If a farmer sees too many disadvantages of SWMP, he is likely not going to invest in them. |
| | Drought-resistant maize difficult to obtain | |
| | Drought resistant crops lower quality and yield than usual | |
| | Grass clover not with weed pressure - extra cost | |
| | Drought-resistant crops need water too | |
| Reason against drainage | Can only be done under turned grass | |
| | Must have ditch | |
| Reason against Water storage | Tried, balloon / dam / culverts / sand, was disappointing, hard to get right | |
| | Had negative effect on other farmers | |
| | Ditch needed for drainage | |
| | Too little effect | |
| | Water board ditch- is up to them | |
| **SWMP – Advantages** | | |
| Reason for other crops | With more frequent irrigation bans you must | If a farmer sees many advantages of SWMP, he is likely going to invest in them. |
| | Grass clover much better against drought - but oppresses grass | |
| | Winter crop future option, but less yield | |
| Reason for drainage | Very good result | |

| | | |
|---|---|---|
| **Typology SWMP** | | |
| 1. Highly drought resilient | | The classification of SWMP for that farmer based on SWMP implemented |
| 2. Midly drought resilient | | |
| 3. Weakly drought resilient | | |
| 4. No drought resilient | | |
| **WMP - measures** | | |
| Irrigated from | Diesel | Semi-structural, but not sustainable – or only sustainable to a degree |
| | Electric | |
| | Ditch | |
| | Well | |
| | Pollution and Quality of well/ ditch water causes use of other | |
| Irrigation system purchased | | |
| **WMP - Disadvantages** | | |
| Reasons against diesel | Irrigation system expensive to buy -depending on how often drought/not for those few years -feed cheaper | If a farmer sees too many disadvantages of WMP, he is likely not going to invest in them. |
| | Irrigation system expensive to operate | |
| | Irrigation system a lot of work, inconvenient , destroys part of maize | |
| | Several installation needed to work properly | |
| | Seen too late = already unsalvageable | |
| | Ban on irrigation too often | |
| Reason against electric | Batteries not feasible/affordable for traditional irrigation | |
| | Needs separate installation points, cannot be done | |
| | Solar panels still too fragile - investment cannot be afforded | |
| **WMP – Advantages** | | |
| Reason for diesel irrigation | Otherwise having to buy feed | If a farmer sees many advantages of WMP, he is likely going to invest in them. |
| | Maize irrigation 'compulsory', otherwise no cob | |
| | Cheaper than drought damage | |
| | Much cheaper watering from well than construction of water storage tank | |
| | Use depends on market value of diesel | |
| | Keeps grass green, does not grow, but no damage and head start | |
| | Cows can stay on the land | |
| Reason for electric irrigation | Batteries feasible for irrigation | |
| | Cheaper than diesel | |
| **Water management general** | | |
| General pro's-Cons | Adaptation must be able to pay for itself - doubts about this | A farmer's general stance on adaptation can serve as an indicator for his willingness to make adaptations |
| | Always enough roughage, even in dry years, no need for adaptation | |
| | Investment in change takes several years | |
| | Can do more, but other things need attention too | |
| | New measures take time, effort and money before it works well | |
| | Nothing better than rain | |
| | Expect drought adaptation to cost a lot of money with more extreme weather | |
| Knows measures via | Approaching LTO | |
| | Pilot farms - workshops - study groups | |
| | Professional journals | |
| | From network farmers | |
| Measures since | >2018 | |
| | 2018-2019 | |
| | 2020< | |
| Sees groundwater level decreasing over years | | |
| Sees impact of sprinkling on (ground) water level | | |

## 2. Coding scheme data analysis

| | | | |
|---|---|---|---|
| **Drought experience** | | | |
| SF | S | IF | I |
| Severe | Not severe | Frequent | Infrequent |
| **Agroecosystem** | | | |
| Enhancing drought risk | Neutral | Limiting drought risk | |
| Ditch available | | No ditch available | |
| **Belief in climate change** | | | |
| Strong belief | Doubting | No belief | |
| **External adaptive capacity** | | | |
| High EAC | Mid EAC | Low/No EAC | |
| **Institutional context** | | | |
| Water authority: enabling | Water authority: neutral | Water authority: hinderance | |
| Government: enabling | Government: neutral | Government: hinderance | |
| **Internal adaptive capacity** | | | |
| Strong IAC | Medium IAC | Low IAC | Limiting IAC |
| **Network** | | | |
| Enabling network | Neutral network | Limiting network | |
| Ancillary function | | No ancillary function | |
| **Risk perception** | | | |
| High risk perception | Medium risk perception | No risk perception | |
| **SWMP** | | | |
| Highly SWMP | Mildly SWMP | Low SWMP | No SWMP |
| **WMP** | | | |
| Harming WMP | Slightly harming WMP | No WMP | |