(Spatial) resilience in the context of drought. Moving beyond the abstractness of the concept of resilience.

A case study of the area of water authority De Dommel in the province of Brabant in the Netherlands

Colophon

Title: (Spatial) resilience in the context of drought. Moving beyond the abstractness of the concept of resilience.

Subtitle: A case study of the area of water authority De Dommel in the province of Brabant in the Netherlands

Author: Remco Bloem
E-mail: R.Bloem.3@student.rug.nl
Student ID: S3497208

Master Program: Environmental and Infrastructure Planning
Faculty of Spatial Sciences University of Groningen

Supervisor: prof. ir. W.L. (wim) Leendertse

Place: Groningen
Date : 28-08-2023

Abstract

The changing climate in combination with a prevailing water-management style of draining the land and discharging the water has increased the likelihood of droughts and their negative impacts through desiccation in the Netherlands, and especially the elevated sandy soil regions. The issues concerning drought affect several sectors such as agriculture, industry as well as drinking water supply, and nature preservation. Due to extended dry periods in recent years, awareness of prolonged periods of droughts and the structural consequences of this through desiccation have grown considerably. In this context, the term resilience is growing in popularity. Despite that, drought governance in the Netherlands, and with it a focus on drought 'resilience', is still in its infancy. At the same time definitions of resilience remain rather abstract in much literature and policy, and elusive to more practical engagement. This research attempts to analyze the concept of resilience in the context of drought via a practical assessment framework and by doing so, move beyond the abstractness of the term.

Key words: Resilience, Drought governance, Desiccation, Robustness, Adaptability, Transformability

Table of content

1. Introduction

The Netherlands is a river-delta with more than half of the area beneath sea-level. Due to this geographical location the country has an elaborate coastal, riverine and pluvial flood risk management, in which the Dutch have been relying on a century-long tradition of fighting the water and trying to control it for which it is internationally renowned (van Brugge et al, 2005; Brockhoff et al., 2022). The Netherlands benefits from these geographical features through the significant freshwater reserves entering the area through rainfall and primarily from its main rivers, the Rhine and Meuse (Van der Brugge et al., 2020). Annually, the country receives a surplus of water equivalent to a water volume of 88 billion cubic meters (Witte et al., 2020).
The design of the water infrastructure and water control was partially because of this, focused on draining the land and discharging the water as soon as possible to prevent flooding as well as organizing and constructing the water system specifically to fulfil agro-hydrological demands through large land consolidation projects. (Van den Eertwegh et al, 2021; Brockhoff et al., 2022). This resulted in an extensive use of canalisation and the protection of surrounding areas by dams and dikes, with as main concern the surplus of water. At the same time, The reduction in the ability to hold water, stemming from the degradation of natural environments and a landscape designed to discharge water, has resulted in pressure from water on land. Consequently, less water is able to seep back into the soil to replenish the groundwater levels. Structural changes in the water system, like the above-mentioned ones, result in desiccation of the landscape, of which the consequences are felt during dry periods (Witte et al., 2020). It is important to note that the distribution of freshwater reserves is not uniform throughout the year, with lower water transportation rates by the rivers Rhine and Meuse and higher evaporation rates during the summer (Van der Brugge et al., 2020). While at the same time precipitation distribution also varies, which is becoming even more uncertain through changes in climatological behaviour (Moradian et al., 2023). Leading to periods with surplus of water and periods with a water deficit.

The consequences of climate change, extreme weather conditions, in relation to land-use functions are also observable in the Netherlands, where more areas are becoming prone to droughts because of decreasing (ground)water levels (Brockhoff et al., 2022). The increasing drainage of the landscape, due to discharging the water and the increasing extraction of groundwater, have led to a situation where on the higher sandy soils of the Netherlands the groundwater levels have dropped about half a meter since 1900, causing desiccation issues (Witte et al, 2020). At the same time, due to relatively long periods of drought in the summers of 2018, 2019, and the spring of 2020, the sandy areas of the Netherlands, located in the eastern and southern parts of the country, were exposed to substantial water shortages (van den Eertwegh et al, 2021). Arisen shortages led to irrigation bans, verge fires, rupturing peat dikes, and dried up waterbodies (Witte et al, 2020).

The imbalance of available water throughout the year, between input (from rain and rivers) and a variety of usage for industry, consumption, agriculture etc. can be partly found in the increasing spatial claims that are made on the limited landscape available in the Netherlands by these usages. The claims made by the different interested sectors, such as agriculture, industry, traffic, housing, and infrastructure, as a result of growing economic development, are posing quite some challenges to the water system, with uncertainties that surround climate change, only making it even more complex (van der Brugge et al. 2007). In addition to that, the expectation is that this imbalance will only increase due to climatological changes in weather patterns and bring new challenges to the area of water management (Van der Brugge et al. 2020). Climatological changes increase the likelihood of more extreme weather patterns, including longer periods without precipitation, affecting the input side of balance. These longer periods of drought result in additional incidents and possible negative effects, which further increases the uncertainty for the water system (Van der Brugge et al., 2005).

Prolonged droughts and the accompanied desiccation can have severe impacts and are among the costliest weather-related extreme events, of which the consequences are manifold (Brockhoff et al., 2022). Examples of this are the loss of commercial shipping on rivers or the need to switch to smaller ships and lower load capacities, due to insufficient water levels (Rijkswaterstaat, 2022). Certain areas, such as the sandy soils of Brabant, even had to deal with far-reaching irrigation restrictions, resulting in losses of crop yield and accompanied economic damage (Volkskrant, 2022). Moreover, the desiccation also has the potential hazard of causing lasting consequences to ecological areas, due to the destruction of sensitive habitats. (Naumann et al. 2021).

Despite the increasing attention assigned to the increases in weather extremes due to climate change, it is worth noting that variations in precipitation levels are not uncommon and were one of the contributing factors in several drought events throughout the last century, such as those experienced in 1911, 1921, 1959, and 1976 (Sluijter et al. 2018). However, the recent succession of dry years, particularly the period between 2018 and 2020 and the year 2022, which registered one of the lowest precipitation levels on record, highlighted that drought is an increasingly pressing issue in the Netherlands (Brockhoff et al., 2022; KNMI, 2022).
Nonetheless, despite the growing sense of urgency, drought risk management has received less attention compared to flood risk management in Northwest Europe. The limited emphasis on drought is not surprising and might find its reasons in the region's ample water resources and the resulting limited awareness and sense of urgency among policy makers and societal actors (Brockhoff et al., 2022). The last couple of years however have established a change in this regard, for at least the Netherlands, with several policy documents and reports, such as Deltaplan zoetwater 2022-2027, Grondwaterconvenant 2021-2027 Brabant, Wateragenda 2030, that emphasize the importance of drought measures. An increasingly mentioned aim in these documents

is the desire to become more robust or resilient to drought problems. However, the exact definition of resilience in this regard is still rather unclear.

Despite the many measures presented in a multitude of reports, the difficulty with this issue is that there is no silver bullet to counter the aforementioned imbalance, since water issues, both too much as well as too little, are interrelated with each other and with other related sectors that are influenced by water. That is why van der Brugge et al. (2015) defines the water problem as a 'persistent' problem. These kinds of problems are "characterized by significant complexity, structural uncertainty, high stakes for a diversity of stakeholders and governance problems", (van der Brugge et al, 2015, p.2) which are deeply rooted in our societal structures and institutions.

The water problem, and inextricably linked to this the drought problem, is persistent because of the multifaceted nature of water. Water possesses numerous manifestations, functions, and values, which leads to the involvement of various stakeholders with divergent interests and high stakes, resulting in a complex and challenging management landscape. Thus, the water problem cannot be viewed as a single issue, as the different forms of water, such as rainwater, groundwater, surface water, and sea water, give rise to distinct problems related to water demand, water supply, water scarcity, wastewater treatment, and changes to the water system (van der Brugge et al. 2007).

According to Brockhoff et al. (2022), drought governance in the Netherlands, and with it a focus on drought resilience, is still in its infancy. The increased sense of urgency has led many scholars and policy makers to search for solutions to the persistent drought problem that the elevated sandy soils of the south- eastern part of the Netherlands are facing and the concept of resilience is certainly one of them. Scientists and policymakers are placing growing emphasis on the importance of building resilience in order to effectively address the uncertainties and complexities of risks resulting from climate change (Rijke et al. 2014).
Resilience in this regard is used as an overarching term that is able to comprise the complexities in a way that has been done by the term sustainability in the recent past (Davoudi et al., 2012). But although the term resilience is strived for in many policy plans and visions, the practical components that contribute to a resilient system are described in inconsistent ways and are often left unexplained (Fünfgeld & Mcevoy, 2012).

1.1 Problem statement

The uncertainty about resilience arises from the varying typology and definitions, such as the engineering, ecology, or evolutionary perspective and how different sectors such as industry, agriculture, government, real estate development etc. interpret or adopt these definitions. Several sectors try to shape resilience by identifying specific indicators and measures that are relevant to that sector. For example, resilience exists in sectors such as flood resilience, ecological resilience and drought resilience. However, this identification of resilience is often rather abstract and without a clear relationship between the measures and indicators that would contribute to the objectives associated with becoming resilient.
This research uses the same reasoning as other sectors, but focuses specifically on the drought problem in relation to space. By doing so, it tries to overcome the abstractness of the term, through defining resilience for the drought context and assessing a framework that links the measures and indicators of resilience to the characteristics and definitions.

1.2 Research aim and research questions

The aim of this study is to asses resilience through a practical framework by which (spatial) resilience in the context of drought can be made tangible and discern practical measures that might contribute to (spatial) resilience in the context of drought, by studying the the case area of water authority De Dommel situated in the province of Brabant in the Netherlands

From this aim the following main research question is derived: How can (spatial) resilience in the context of drought be defined and what measures might contribute positively to achieving (spatial) resilience in the context of drought?

This main research question is subdivided in the following secondary research questions:

- 1: What is meant by drought and desiccation and how does this relate to the area?
- 2: What is the definition of resilience in the context of drought?
- 3: What goals are set in tackling the issue of drought in the case study?
- 4: Which components (physical and social) contribute to resilience in the case study?

1.3 Scientific relevance of the research

Much focus in the Netherlands concerning water is focused on flooding. Only recent this is shifting towards the drought issue. Bordering countries such as Belgium and Germany also experience similar problems and are therefore also interested in this line of research.
This research elaborates on building spatial resilience in the face of drought.

Surprisingly, only a limited number of publications focus onthe practical implementation of a resilience-oriented planning approach concerning the increasingly topical drought problems in the Netherlands, which are present especially on the elevated sandy soils. At the same time definitions of resilience remain rather abstract and elusive to more practical engagement.

As a concept that has the potential to transform the framing of planning problems and interventions, and that is increasingly mentioned in policy plans, a more tangible definition of resilience in the context of drought could be relevant for the academic field.

1.4 Societal and practical relevance of the research

The issues concerning drought affect several sectors such as agriculture, industry as well as drinking water supply and nature preservation, but also real estate development and road-infrastructure. Fresh water is an essential element in almost every aspect of life. A better understanding of (spatial) resilience in this context would therefore benefit everyone in society in some form or manner.

The goal and societal relevance of this research is to move away from the abstractness of the term resilience, and create a more practical understanding and to avoid the tendency of different stakeholders in the matter to move into their own views, which reduces the progress in becoming more resilient against droughts and its accompanied uncertainties.

1.5 Reading guide

This research is carried out in three parts. Within the first part, a literature scan is conducted and the concepts of drought and desiccation are explained, the theoretical context of a socio-ecological system is described as well as resilience its definitions, characteristics and components. In the second part the methodology is described and includes a description of the selected case study including a historical case study analysis. The third part focuses on the results and shows the findings of the interviews and document analysis structured on the basis of the theoretical framework and the measures proposed in the different policy documents. In the last section a discussion on the literature from the results is provided and some concluding remarks are given.

2. Theoretical Framework

2.1 Droughts and desiccation

Due to this lack of clarity, drought can have various definitions and meanings that are often linked to particular requirements or fields of study (Rijke et al., 2014). Drought is the result of an unusually prolonged dry period with lack of precipitation, that differs from the normal situation thereby disrupting the natural hydrological balance (van den Eertwegh et al., 2021).

Due to the difficulty of precisely identifying a starting point or an end of droughts, droughts are commonly labelled as a "creeping phenomenon" (Wilhite & Buchanan-Smith, 2005; p. 5). Rijke et al. (2014), makes the observation here that, unlike floods, which can pose immediate, physical dangers such as waves or water bodies, droughts are perceived as situations that start during normal or predicted moments of precipitation and may take a while to materialize (Wilhite, 2009).
That is why there is not just one, but several ways a drought could be measured. According to Wilhite and Glantz (1985), there are four types of measuring droughts that are most common. These are: meteorological, hydrological, agricultural and socio-economic. The meteorological, hydrological and agricultural types of measuring focus on the physical traits, while the socio-economic type looks at how it affects the economic needs associated with the needs of people and the environment. For this research the socio-economic type will be used, as this incorporates the sociological part and therefore corresponds best with the SES perspective that has been chosen. The distinctions in measurement methods between meteorological and hydrological were also mentioned in van den Eertwegh et al., (2021), where they explained the drought development as a phenomenon that manifests itself in different compartments of the water cycle. Although an exact starting point is difficult to define, it often starts with a meteorological drought that arises from a lack of precipitation in combination with high levels of evaporation (van den Eertwegh et al., 2021). This situation of high demand and low supply leads to a sharp reduction in the amount of water. The next step in the drought development is the hydrological drought, in van den Eertwegh et al. (2021), also referred to as the soil moisture drought. In this situation the difference between precipitation and evaporation causes the soil to dry out. This process of decreasing soil moisture starts with the top layers on the surface where vegetations has its roots, and continuous to deeper layers where it eventually depletes the ditches, streams and larger watercourses. In these successive situations of three connected compartments (soil water, groundwater, surface water) it takes longer and longer for the meteorological drought to propagate. Similarly, in this order, it also takes longer for a compartment to recover from a drought, especially if a soil-groundwater system is deep (van den Eertwegh et al., 2021). It can therefore be stated that the effects of drought cannot be seen as an isolated phenomenon, but are connected to the state of the soil-water system. The expectation is that, the already complex and uncertain creeping phenomena that drought is, will only increase due to
climatological changes in weather patterns and will impose other situations and challenges for water management. Longer periods of drought will cause increasing incidents in this dimension of the water problem and possible negative effects, which further increases the uncertainty for the water system (Van der Brugge et al., 2005).

When the consequences of external events have a more structural impact on the watercycle, then this is indicated by the term 'desiccation' (Witte et al., 2020). In policy legislation desiccation is referred to by (Ministerie van verkeer & waterstaat, 1994 p.164), as: "A nature reserve is considered to be 'desiccated' if the amount of available groundwater of the right quality is insufficient to guarantee the natural values. An area is also considered to be desiccated if water of a different, foreign quality has to be supplied due to groundwater levels that are insufficient or too low for vegetation to reach or if seepage pressure is too low to reach rootzones. According to van den Eertwegh et al. (2021), the term desiccation is therefore automatically linked to nature.
The presence of desiccation, in contrast to drought, has to do with how a socio-ecological system operates and how the sociological is influencing the ecological. Due to the increasing drainage of the Dutch landscape and the rising usage of groundwater extraction, the groundwater level in the higher sandy soils of the Netherlands have dropped by approximately half a meter since 1900 (van den Eertwegh et al., 2021; Witte et al., 2020). The term desiccation, therefore, has nothing to do with a precipitation deficit. In a situation, for example, where the agriculture is having water deficiency this is not considered desiccation, but has to do with drought (van den Eertwegh et al., 2021). Desiccation, in this context, specifically pertains to regions that naturally maintain a particular groundwater level. These areas have evolved to thrive in such conditions, but when human activities cause a decrease in water availability, the delicate balance is disrupted, leading to drying out of the ecosystem. Desiccation not only results in environmental harm but also poses significant risks during periods of drought, causing structural damage to nature's intricate systems. Desiccation therefore, as mentioned briefly in the introduction, can be seen as a consequence of a water management style that is focussed on draining the land and discharging the water for flood protection, but mainly land consolidation reasons (van den Eertwegh et al, 2021; Brockhoff et al., 2022).

Climate change and the increasing accompanied droughts can therefore be seen as one of the factors that expose and reinforce the uncertainty that a system experiences. However, climate change and prolonged periods of drought would have less impact on a system if it was less vulnerable. Besides the increasing evaporation, Desiccation can partly be seen as a consequence of interventions in the landscape due to certain management choices from the sociological dimension and increasing usage from the societal dimension, which in turn is increasing the vulnerability to droughts of a system. Drought in this regard is the phenomena that a system is trying to become resilient against and which increases the uncertainty at the same time. Desiccation is a situation where groundwater levels are structurally lower than usual unrelated to a lack of water, which has to be supplemented with water of foreign quality to prevent drying out of vegetation or the in ability to prevent this from happening. It can therefore be seen as an indicator that shows that the balance, in the amount of water that enters the area and is required for socio-ecological purposes, is disrupted by the human intervention in the landscape through their water management of discharging the available water to fulfil agro-hydrological demands and large land consolidation projects for several land-use functions. (Van den Eertwegh et al, 2021; Brockhoff et al., 2022).

To summarize
droughts are commonly labelled as a "creeping phenomenon that lack a specific starting point. However, considering that drought is only an issue when a system in no longer in balance, the exact starting point is not considered necessary knowledge but merely a finding in the detected imbalance.

The most important measuring type of drought for this research is the socio-economic type, which looks at how droughts affect the economic needs associated with the needs of people and the environment. Socio-economic drought is also considered most relevant for this research as it has significant impacts on the social and economic aspects of a region or community. It extends beyond just the physical scarcity of water and encompasses broader implications, such as reduced agricultural productivity, economic losses, food security challenges, and societal disruptions. Since these aspects are included in the SES and interrelatedness is important characteristic in these systems, ignoring these aspects would not lead to the desired outcome.

2.2 Socio-Ecological systems

The characteristics of the persistent ‘water problem’: significant complexity, structural uncertainty, high stakes for a diversity of stakeholders and governance problems are all interlinked with each other. (Van der Brugge et al, 2015). The expectation is that the imbalance in water availability at certain times, for the current needs in society, will only increase due to climatological changes in weather patterns and bring new challenges to the area of water management (Van der Brugge et al. 2020).
Therefore, the complex problems surrounding droughts and desiccation and the uncertainties surrounding this, are all part of a socio-ecological system (SES), of which citizens, the climate and urban environment are again all part. In other words, the sociological and ecological parts cannot be seen as different systems, but are intertwined with each other and affect each other because of that. Berkes, et al. (2008), state that, throughout human history, there have been significant events and regional alterations that affected the capacity of the ecosystem to sustain sociological structures. Back then, they state, nature's resilience had been strong enough to maintain relative stability in many respects, as changes were mitigated by the resilience of a system. However, their current perspective is that this situation has changed due to human dominance over ecosystems. When it comes to resilience of the drought perspective, the excessive drainage of water for safety and land consolidation reasons could be seen as a human dominance over the ecological side that disturbs the balance. The drainage instruments implemented decrease the retaining capacities of the land, compared to that of a natural situation.

The landscape and waterways undergo interventions due to various demands from sectors such as agriculture, industry, traffic, housing, and infrastructure, driven by rapid economic development. These interventions present significant challenges to the water system, potentially disrupting its balance and stability and increasing its vulnerability (Van der Brugge et al. 2007). Therefore, in order to prevent increasing vulnerability of the well-being of human society to climate change, a shift is necessary in the perspective on society towards a system consisting of complexity that incorporates the consequences of interventions on the entirety of a system (Berkes et al., 2008). There should not only be a focus on either the ecological part or the sociological part of the system but on the socio-ecological system. Such a socio-ecological system refers to the interaction between ecological and sociological systems, including a cultural, political, social, economic, ecological, technological, and other components, on a specific scale, which can occur at a local or global level (Walker et al., 2010). The SES is complex, due to the interconnectedness of the parts and the non-linear effects that they have on each other (Berkes et al., 2008).

Similar characteristics are present in the water issue, defined as a persistent problem by
Van der Brugge et al. (2015). The “*significant complexity, structural uncertainty, high stakes for a diversity of stakeholders and governance problems*” asks for a perspective that also incorporates these concepts (Van der Brugge et al, 2015, p.2). The fact these issues are deeply rooted in societal structures and institutions shows that merely looking at the physical is not sufficient to address the issue.
Due to this interconnectedness and its related interactions, SES’s have the ability to self-organize. When different parts of a community and their environment interact, they can naturally adjust and create new ways of working together. This can be tricky to manage, but it also means there's a chance to bounce back after something disrupts the system (Walker et al., 2010). When a system is not stable in its current form it could therefore potentially also change into a state that is. To understand and anticipate the actions of sociological and ecological components within the socio-ecological system therefore often requires looking at both components at the same time, as sociological and ecological components their interplay results in the outcomes perceived, such as the desiccation problems especially occurring during periods of drought. The way the socio-ecological system for the water perspective is designed makes it more vulnerable to drought due to the desiccation, but the uncertainties of the changing climate expose these vulnerabilities increasingly to the

surface.
With regard to the situation surrounding drought, it could be stated that this is currently out of balance, which is reflected in shortages for the current functions related to water and the decrease in biodiversity and drying out of nature. For example, it could be argued that the ecological side is losing out at this moment due to the gradual dimmish of area and species (Naumann et al. 2021). The changes in the spatial environment due to the design of the ecological landscape as a result of sociological wishes cause an imbalance. Difficulty in restoring the resilience again to make the system more in balance might find its origin in the lack of a clear picture of what resilience means in this situation and therefore makes it harder to strive for from a sociological side.

According to Walker et al. (2010), once the main issue has been determined, in this case the drought issue, It's important to pinpoint the essential components of the socio-ecological system that relate to the main issue. For the drought issue, for example, this could entails key issues, such as watermanagement, the increasing unpredictability due to climate change. Components that affect the situation should also be address, such as, for example land-use functions and other biophysical properties (ecological) and the sociological ones

According to Walker et al. (2004), the stability dynamics of interconnected human and natural systems arise from three interrelated qualities: resilience, adaptability, and transformability. Gaining familiarity with these concepts offers a valuable means to acquire deeper insights into the system and minimize uncertainty. At the same time, it provides a more holistic perspective on resilience and its relation to other concepts in the socio-ecological system. Resilience in this regard can be seen as a system property and refers to how much a system can handle changes or disruptions before it completely transforms into a different state, with new structures and functions that provide different types of benefits to humans. (Walker et al.,2010). Therefore, a SES perception is central to resilience thinking. Walker et al. (2004), do make a distinction between resilience and adaptability on the one hand and transformability on the other. According to them, resilience and adaptability are about how a specific system, or a group of connected systems, can change over time, without losing their predefined functions. Transformability, on the other hand, means the ability to change the way a system works. It is important to look at resilience from a systems perspective because of the interrelatedness of the social and ecological parts. This is the case because a system may be resilient in an ecological way, but socially undesirable, or they might have resilience in a social way, but they have a negative impact on their environment (Walker et al., 2010).

To summarize, the following characteristics of an SES are most relevant for the drought issue:

Interconnectedness: Socio-ecological systems recognize that social, economic, and ecological components are interconnected and interdependent. Changes in one component can lead to ripple effects throughout the system. SES recognize that humans are not just external actors influencing ecosystems, but are integral parts of those ecosystems. Human activities have profound effects on ecological processes and vice versa. Tackling the drought issue and realising resilience should therefore encompass all components.
Complexity: Socio-ecological systems are characterized by their complexity due to the multitude of interactions and feedback loops between human and ecological elements. The unpredictability that follows from these loops should be considered in the degree of strictness that is aimed for in the approach of certain goals that are set and maintain some flexibility.
Uncertainty: Uncertainty is inherent in socio-ecological systems due to their complexity and the dynamic nature of their components. Managing uncertainty is a key challenge in decision-making and planning. As with complexity, it is important to integrate flexibility into the approach of goals because of the uncertainty.
Adaptability: Socio-ecological systems have the capacity to adapt to changes and disturbances, whether they are environmental, economic, or social in nature. This adaptability is crucial for maintaining system resilience.
Resilience: refers to a system's ability to absorb shocks, maintain its basic structure, and recover from disturbances. Socio-ecological systems aim to enhance resilience in both human and ecological dimensions.

2.3 Definitions of resilience

2.3.1 What is resilience ?

As mentioned in the introduction the prevailing water management style of discharging the water as soon as possible, together with intensive land-use functions on limited space, resulted for the Netherlands in drought related issues, referred to as desiccation, in the elevated sandy soils of the southern and eastern part during dry periods. This has only been exacerbated due to weather extremes and a changing climate, making the issue of drought more pressing. Facing these climate issues, one conclusion some scholars and policy advisors came to is that there is a necessity to adapt. In the context of climate change, according to (Fünfgeld & McEvoy, 2012), the concept of adaptation can be described by using scientific terminology, such as vulnerability, exposure, sensitivity, adaptive capacity, and more and more frequently 'resilience'. These concepts stem from various academic disciplines, however, Fünfgeld & Mcevoy (2012), view these concepts as gradually becoming interchangeable despite their origins in various fields of study. This suggests that these concepts, while distinct in their own right, have overlapping meanings and therefore differ only slightly with regard to their academic angle.

Over the past decade, the use of resilience in policy and practice has increased, in which resilience is largely seen as a response to climate change, its uncertainties and socio-economic insecurities (Davoudi et al., 2012). The increasing weather extremes, climatological changes and the accompanied uncertainty, results in SES that are no longer able to successfully realize all their tasks in their original functioning. To be able to meet all requirements for water availability, such as drinking water supply, and water demand from industry, agriculture and ecosystems, despite the increasing uncertainties, many policy makers are looking for a way to become more resilient. Resilience in this sense is a system property of a socio-ecological system that contributes to absorbing the (increased) uncertainties surrounding the water system due to climate change.

According to Davoudi et al. (2012), the difficulty of tackling climate change isn't that we need completely new ideas, methods, or policies, but that it involves crossing over the lines between different scientific fields and government departments that focus on specific areas.
The reason why the concept of resilience is in demand in this regard, might be that it is flexible enough to bridge the gap that Bristow (2010, p. 163), mentioned as the ''grey area between academic policy, practice and discourse''. One of the explanations for the increased usage of the term resilience might be that a key feature of resilient approaches, according to Adger (2010 p.1), is the flexibility to "adapt to changed circumstances, to change, rather than to continue doing the same thing".

This is important because tackling the drought problem with all its uncertain interrelations and influences such as climate change and the effects of different land-use functions, asks for incorporating a multitude of information from varying levels. As well as collaboration between a wide array of stakeholders, to create viable strategies and measures that meet social and political standards, even though there is considerable uncertainty. In the article of Berkes et al. (2008), resilience is even seen as a key property of sustainability, and that loss of resilience would lead to a reduced capacity to deal with change.

In many cases however, resilience is not used in a very specific way, but often placed as a general broad term that somewhat resembles the characteristics of the concept adaptability, rather than being precisely defined.
Following this, Davoudi et al. (2012), made the observation that resilience is increasingly replacing sustainability and is used in a similar way in everyday conversations. The adverse effect of the term's inclusiveness, however, is that the same qualities that make it appealing to many issues, also result in an abstract definition and vagueness surrounding its implementation (Davoudi et al., 2012). The abstractness of the term and absence of a clear definition add to the difficulty of real-world implementation and its ability to provide practical tools (Davoudi et al., 2012).
Wilkison (2012), also noted a gap between the promotion of social ecological resilience in scientific literature and its use in policy discourse and the concepts' proved ability to effectively govern for resilience in practice.

But despite this uncertainty surrounding the meaning of resilience, there is an increasing number of reports that strive to achieve resilience and aim to develop practical toolkits for resilience building to realize this (Davoudi et al., 2012). To get a better understanding of how resilience could be achieved, it is first and foremost important to understand the multiplicity of usages around the concept and how this relates to the various definitions that resilience has and their origin (Fünfgeld & Mcevoy, 2012).

Walker, et al., (2004 p.2) frame resilience as: "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks—in other words, stay in the same basin of attraction". Which can be translated into, the ability to recover from an external shock. In that sense it can be viewed as the opposite of an often-mentioned attribute of a system, namely resistance, which is the ability to preserve the current state (Vis, et al., 2003). The relationship between adaptive capacity (or adaptability) and resilience is unclear because there are varying opinions. Some experts consider adaptive capacity to be equivalent to resilience and social resilience (Smit & Wandel, 2006). Others view it as the strength of a system during changes in resilience, in other words, robustness. Additionally, Carpenter et al. (2001) perceive adaptive capacity as a component of resilience, focusing on a system's ability to learn from disruptions. Lastly, walker et al. (2004), view adaptability as the ability of a community to collaborate and manage resilience.

These varying viewpoints on essentially similar concepts highlight the absence of a generally accepted definition for these. This lack of a common understanding of these concepts can already be observed when looking at them individually, but becomes even more clear when viewed in relation to each other (Gallopín, 2006). Therefore, this research focuses on three definitions of resilience described in Davoudi et al. (2012).

The first appearances of the concept of resilience in its current understanding emerged in the article of Holling (1973), in which he made a distinction between an engineering form of resilience and an ecological form. Later a third definition was added in the form of evolutionary resilience. In general, the resilience literature distinguishes three different definitions of resilience. The first, which still holds significant influence in practice, is referred to as "engineering resilience." It emphasizes the ability to withstand and overcome risks by implementing primarily technical measures that prioritize resistance and robustness. (Davoudi et al., 2012; Holling, 1973). Other interpretations of resilience are, ecological resilience, which considers spatial as well as ecological aspects in risk management and has adaptability as a main characteristic, and evolutionary resilience which transcends the previous definitions by adding the ability of transformability to this (Davoudi, 2012;2013). In the following sections, I will further elaborate on the definitions of resilience mentioned above and their properties and components.

2.3.2 Engineering resilience
Davoudi et al (2012), explained engineering resilience based on the article of Holling as the ability of a system to

return to an equilibrium or steady state after a disturbance (Holling, 1973, 1986). Such disturbances are also known as shock events and are here referred to as: ''certain physical events, evidently from outside the social domain, but possibly influenced by it (Wiering & Immink p.426).

According to the engineering view, resilience is measured by a system's ability to withstand a shock event, as well as how quickly it is able to bounce back to its equilibrium. With this type of resilience, a system has a singular equilibrium point to which the system rebounds after a shock (Davoudi et al., 2012).
The emphasis with this definition seems to be mainly on technical systems with clear inputs and measurable parts, considering related terms used in Holling (1996, p. 31), such as "efficiency, constancy and predictability". Which was in Laeni et al. (2021), mentioned as an emphasize on the robustness and resistance of a system.

According to Folke et al. (2010), numerous present strategies employed by nation states and related organizations share a general comprehension of resilience as the ability to withstand shocks and maintain current conditions, as well as bounce back from disruptions and return to previous levels. Which bears resemblance to the engineering definition of resilience, due to the aim of a return to its equilibrium. Furthermore, A common observation by Pendall et al., (2010), is that besides the agreement about returning to a systems equilibrium often referred to as back to 'normal', there is hardly any indication of what this 'normal' exactly means. This tendency to focus on a return to 'normal', often results in the consequence that decision-making is also formed with this mentality by responsible authorities.
A similar phenomenon, where a focus on returning to a familiar form of 'normal' is strived for, can also be observed in the literature written on resilience. Here, according to Davoudi et al. (2012), The resilience-building literature tends to prioritize planning for post-disaster emergencies, with a focus on addressing sudden, turbulent, and large-scale events, while overlooking the importance of addressing gradual, small, and cumulative changes. One of the key features, mentioned here, of such an approach is that it creates a focus on short-term damage reduction, but does not contribute to long-term adaptive capacity building that is especially crucial for complex issues that contain a lot of uncertainty (Davoudi et al., 2012). Especially when dealing with uncertainty and complex interconnected systems, an engineering resilience perspective, of conserving the status quo, encounters some contradictions between the desire to return to 'normal' from the engineering perspective and the absence of certainty and control in interconnected complex systems. This is also why with engineering resilience, in general, those in decisive positions within organizations tend to view significant transformations as a sign of system failure rather than recognizing it as a natural aspect of maintaining resilience (Porter & Davoudi, 2012).

2.3.3 Ecological resilience
Another definition of resilience mentioned by Holling (1996), is that of ecological resilience. Resilience in this form refers to spatial as well as ecological aspects in dealing with issues caused by shock events and was described as "the magnitude of the disturbance that can be absorbed before the system changes its structure" (Holling, 1996, p. 33). Resilience in this definition takes the property of engineering resilience, which looks at the return time of a system after a shock event, and simultaneously looks at how much disturbance a system is able to handle before changing form to determine how resilient a system is (Davoudi et al. 2012). Adger (2003, p.1), referred to this as: "the ability to persist and the ability to adapt".

Ecological resilience differs from the engineering perspective in the sense that this viewpoint challenges the idea of a single, stable equilibrium and recognizes the existence of several possible equilibria, as well as the potential for systems to shift to a different form of equilibrium or stable balance point. So rather than returning to a previously known point for a system, the idea with ecological resilience is that, when a system has to deal with an event that throws it of balance, it bounces forward to a new kind of stable balance point in the system (Davoudi et al., 2012). Striving for resilience in a system, when looking at planning for the spatial area and its theory, this definition could provide a new way of approaching the spatial domain. Rather than designing a system in a way that steers towards a system to return to its original state with technical measures after an external shock, the ecological view of resilience could provide the spatial planner with a view that is directed to bouncing forward. In such a situation the system could be designed in a way that allows it to respond to crises by adapting to a new state that is better suited to the current environment and more sustainable over the long term (Shaw, 2012). According to Laeni et al. (2021), in relation to flood risk management, this interpretation of the term resilience highlights the significance of an integrated approach that also emphasizes the importance of adaptability, rather than relying on technical flood protection strategies alone that are more commonly associated with an engineering perspective on resilience. Ecological resilience has the additional ability to adapt and re-organization after such disturbance. Ecological resilience relies on the overall system's flexibility and capacity to adapt, in contrast to the engineering resilience approach, which primarily focuses on reinforcing structures. (Carpenter et al., 2001).

A similarity between the engineering and ecological perspectives on resilience, is that both perspectives recognize the existence of a balance point or equilibrium of a system in their definition of resilience (Davoudi et al., 2012). The concept of resilience based on equilibrium, as found in both definitions, stems from the idea that the world can be explained following natural laws and therefore some sort of exact truth can be achieved. This is also described as a Newtonian world view and is based on predictions by mathematical rules that see the world as a mechanical system that, therefore, can be monitored by command-and-control systems (Davoudi et al., 2012). This view, however, is in conflict with the understanding of the world following the complexity theory that sees the world as unpredictable and made up of many interacting components, such as social, ecological, and economic systems (Davoudi et al., 2013).

2.3.4 Evolutionary resilience
In addition to the above-mentioned definitions of resilience, Davoudi et al. (2012) refers to a third perspective, namely evolutionary resilience. Different from the equilibrium-based definitions of resilience describe above, the evolutionary perspective of resilience questions the entire idea of a stable equilibrium point. The idea here is that the nature of a system is in constant change which is not necessarily influenced by a shock event of an external nature (Davoudi et al., 2012). This definition of resilience does not only include the robustness characteristic described in the engineering perspective, and the adaptability characteristic that was added to the characteristics at the ecological perspective, but also includes the ability to transform in the face or unsustainable situations. The convergence of these properties in this form of resilience is the result of the desire of adapting to climate change, since this challenge is not just a technical or environmental challenge, 'but a social, political and normative challenge', as well (Davoudi et al., 2013).
In this perspective of resilience, there is a strong focus on the collaboration among stakeholders for policy adjustment and long-term institutional change to deal with the interconnectedness of many issues and the uncertainty that arises from this (Laeni et al, 2021).
According to Davoudi et al. (2012), this idea of resilience isn't viewed as a restoration of the status quo or a 'normal' of which a clear definition is in most cases lacking, but rather as the capacity of complex socio-ecological systems to change, adjust, and, as mentioned above, undergo transformation when a system is under pressure or the current situation is unsustainable (Carpenter et al., 2005). Or as Davoudi (2018, p.4) stated it, "the capacity to break away from an undesirable 'normal''. That is why, different then with the engineering perspective, If, after a shock event, a system transforms into something different, this is not seen as a failure in the evolutionary resilience perspective, but a normal turn of events (Porter & Davoudi, 2012).
The evolutionary perspective reflects a paradigm shift in how scientists think about the world and finds its origin in the long-standing criticism that complexity theory has on the Newtonian world view based on natural laws. Different from the mechanical view of systems based on mathematical laws, this theory sees complex systems as: ''non-linear, discontinuous, self-organizing, emergent and inherently unpredictable" (Davoudi, 2018, p.4). One of the most important characteristics of this perspective on resilience and its view on socio-ecological systems is that systems are always in a state of change and that transformation is an important part of the process. (Fünfgeld & Mcevoy, 2012).

Besides the different perspective on equilibria, there are also other different ways of analysing a systems' behaviour that is present with the evolutionary resilience definition. According to Davoudi et al. (2012), for example, the evolutionary resilience definition implies that change does not merely results from external events but can also happen due to internal stresses that do not have the usual cause-effect relationship. Furthermore, the evolutionary perspective, in line with the aforementioned character traits, has According to Duit et al. (2010, p. 367), the belief that "past behaviour of the system is no longer a reliable predictor of future behaviour even when circumstances are similar" (Davoudi et al., 2012).

This view on the predictability of potential future scenarios expresses some doubts about whether or not the conventional way of approaching issues, such as extrapolating past trends to determine possible futures, is a realistic manner for reducing uncertainties. In relation to the planning realm this definition, according to Davoudi et al. (2012), therefore moves away from the idea that places are neutral containers that can be analysed following assumptions based on the past, but moves beyond that to an notion of spatial locations as: "complex, interconnected socio-spatial systems with extensive and unpredictable feedback processes which operate at multiple scales and timeframes" (Davoudi et al., 2012, p. 304).

At the core of both the sociological and ecological aspects of resilience lies the concept that ecosystems or groups have the ability to endure or adjust to stress without experiencing significant damage to their functionality. Translating this idea to an area and the subject of drought resilience, this would entail that an area takes the necessary precautions to prevent the impact of drought by adapting land-use functions to prevent desiccation and this way suffer less in case of a drought event.

However, despite quite some extensive research on the topic of resilience, due to the ambiguity of the concept, research has largely focused on exploring the meaning of resilience (Restemeyer et al., 2015)
Looking at these different definitions, resilience is approached in a fairly abstract manner and doesn't go much deeper than an abstract umbrella term that can generally be defined as "the capacity of a system to resist or withstand shocks and disturbances as well as the ability to adapt and transform to changing socio-ecological conditions" (Laeni et al, 2021, p. 17). In the next paragraph, I will therefore discuss the more practical aspects of resilience, by zooming in on the characteristics of the concept as mentioned in literature.

2.4 Characteristics (attributes) linked to the definitions of resilience
To achieve resilience or become resilient, several properties or characteristics are mentioned in the different definitions of resilience that were mentioned above.
in the article of Restemeyer et al. (2015), a clear distinction is made by means of concepts. The concepts, that represent characteristics of resilience, which are elaborated upon in the article of Restemeyer et al. (2025),

provide a clear categorisation for measures used in practice that could be implemented to strive for resilience. At the same time, they provide a link to the above described definitions through similarities between the characteristics they represent . Therefore, I will further subdivide resilience using this division to make the term more concrete. Restemeyer et al. (2015), refer in their article to the characteristics robustness, adaptability and transformability.

Robustness, in the context of resilience, refers to the concept of "persistence" as defined by Holling (1973) and Davoudi et al. (2012), which can be understood as the ability of a system to resist external events. It can also be referred to as "rigidity", which is a system's capacity to endure a certain level of stress (Davoudi et al., 2013). This characteristic, although part of all the above-mentioned definitions, is most evident in the engineering perspective on resilience, due to the technical nature of the measure employed here. That is why, in order to become robust, most often technical measures such as dyke improvements, locks, pumps and other physical interventions in the system are used to resist impacts of a potential shock event (Restemeyer et al., 2015). That does not mean however that it is not possible to build up social robustness, although this is mentioned significantly less.

Adaptability on the other hand is referred to as the ability to make adjustments within a system that make it less vulnerable to external events. Restemeyer et al. (2015), describe in their article a more practical example to become more adaptable. They stated that to become more adaptable an adjustment of the physical environment as well as the social sphere is required. In their case study based on flood risk management, this meant that a resilience approach based on adaptability would take a flood event (or another externality) into account. Because this characteristic of resilience recognizes the possibility of an event happening, it adapts the land-use functions in order to minimize the potential harm an event can cause (Restemeyer et al., 2015). This corresponds most with the ecological definition of resilience, although robustness is also a property that falls under this definition. Adaptability is important in this regard, due to the acceptance of an uncertain equilibrium, when faced with a shock event. When uncertain about the outcome of a threat to a systems equilibrium, creating adaptability can reduce the impact it has.

The characteristic transformability refers to the possibility of a transition to a new system “when ecological, economic, or social structures make the existing system untenable” (Restemeyer et al., 2015, p.14). It is this characteristic that distinguishes the evolutionary perspective from the other definitions of resilience. Davoudi et al. (2012;2013), explain evolutionary resilience, and its main characteristic transformability, by referring to the panarchy model created by (Holling & Gunderson, 2002). This model presents a dynamic and unpredictable process of change in which the system transitions to a completely new state. With this characteristic, risk management goes beyond the interventions by planners who intervene to make a system more resilient, and thinks this task requires society-wide efforts that involve collaboration across different disciplines. Transformability could be seen as an extension of the aforementioned properties, as it requires changes in the physical and social environment (Restemeyer et al., 2015).
Changes such as technical measures in the landscape to create robustness, as well as changes in the land-use functions and mindsets that are part of the adaptability characteristic. These changes need willingness from a society to become reality and so without transformability in the physical and/or social sense, a system will not be able to change towards a more resilient system. However, the future will bring new insights, necessitating further transformation. Transformability involves embracing change based on these insights and finding the best way to tackle external risks (Restemeyer et al., 2015).

The interconnected nature and uncertainty highlighted in section 2.1, regarding resilience, robustness, adaptability, and transformability, are also observable in the practical implementation of the resilience concept. In the context of "robustness and adaptability," the focus is on minimizing vulnerability by enhancing the system's resilience. On the other hand, "transformability" leans toward enhancing adaptive capacity (or adaptability) (Walker et al., 2010).
Although being slightly less abstract than the definitions of resilience themselves, the properties of a resilient system, such as robustness, adaptability and transformability, are not very specific either. To get a better practical understanding, it therefore feels necessary to go into more detail and search for components of these characteristics.

2.5 Resilience and the measures and indicators of its characteristics

Looking at the concept of resilience several definitions have been mentioned and these definitions represent certain characteristics. These characteristics however, can also be linked to practical measures and indicators that reflect the success of these measures. Resilience is not a means, but a desired situation. When a system is not in balance and the negative effects of this are felt, a certain objective could be set to return to a situation where the system is resilient again. Indicators could show where a system is already performing well and in which situations action is needed. Measures can then be created to steer a system in the right direction.
In that regard, these characteristics and measures are actually nothing but the bundling of indicators. It is a sorting of indicators to somewhat structure the different components. In the next parts general types of measures are mentioned and sorted based on the article of Restemeyer et al. (2015).
The difficulty in this, is dealing with complexity and uncertainties. The earlier mentioned ‘persisent problems "characterized by significant complexity, structural uncertainty, high stakes for a diversity of stakeholders and

governance problems", (van der Brugge et al, 2015, p.2), make it hard to determine which of the measures are working for which specific indicators. Making drought management a complex endeavour. Therefore, Rijke et al. (2014), mention that to become resilient in water management, it is necessary to integrate with other sectors, such as urban development and especially land use planning.

Robustness:
In their article, Restemeyer et al. (2015) mention that the acknowledgment of the necessity for a certain robustness in a resilient city, and the technical measures such as dikes, dams, and sluices that contribute to this resilience, can be seen as an inherent component in achieving resilience. Besides the technical measures, robustness includes also another component described in this article, namely spatial measures (Restemeyer et al., 2015). For drought, these could be technical measures such as water storage and other interventions that keep water in the area for prolonged periods of time and serve as a buffer to withstand drought problems and prevent desiccation, by restoring some of the imbalance of water availability though out the year. The creation of surplus of water in a system to withstand subsequent droughts is a form redundancy or abundance. This is also one of the components that can be used to realise resilience and, depending on which angle you look at it, fits best within the robustness property. Redundancy, however, often isn't limited to one thing, in fact, the more diversity is present in a system, the more resilient it is perceived. A negative externality of this redundancy on the other hand, could be that this abundance in one area, might have consequences for another (Wilkinson, 2012).

Adaptability:

Components that are mentioned in relation to the characteristic of adaptability are, for example, the Discouragement of vulnerable land-use in drought prone areas, the adjustment of functions in order to make them better suited for droughts and instalment of drought insurance and recovery funds (Restemeyer et al., 2015). Insurances and recovery funds could contribute to a more resilient system because, although they do not reduce the physical impact of an event, they allow the affected citizens to recover more quickly and therefore the system to return sooner to an equilibrium (Restemeyer et al. 2015).

Transformability:

The transformability characteristic of resilience differs from the rest of the characteristic in the sense that the components that contribute to resilience are slightly more complicated than the ones of the previously mentioned robustness and adaptability. Transformability is twofold in its practical success. On the one hand the characteristic of transformability necessitates a reimagining of responsibilities surrounding risk management and how these issues are handled and by who. To do this it also needs capabilities such as knowledge, creativity, and visionary thinking to develop innovative solutions. This is the mentality change, social side of the equation. On the other hand, for its successful implementation, and realisation of societal change, it requires certain pressure to do so. According to Restemeyer et al. (2015), in order to achieve true transformability, it is necessary to have power, resources and public support. The main factor that determines the success of transformability, however, is the ability to cultivate a shift in societal norms and values, as altering people's behaviour and mindsets is a fundamental prerequisite for bringing about tangible change within a system (Restemeyer et al., 2015). That is why Restemeyer et al. (2015), state that the process of creating a resilient system is a challenging and demanding endeavour that cannot be accomplished through a simple checklist of measures alone, it would additionally also require a shift in mindset to one that is more open to collaboration across various disciplines and to ensure that citizens understand their role within the system. Some more practical components that are mentioned to realize transformability are ones such as risk communication and awareness raising among: private stakeholder, though brochures, public campaigns, early education in school. As well as public stakeholders through consensus building, partnership practices and decision support tools. Besides that, awareness raising and empowerment of local residents, such as brochures and public campaigns, are also presented as contributing components of the societal change necessary for successful transformability (Restemeyer et al. 2015).

Measures and indicators of the Characteristics (Restemeyer et al. 2015)			
Definitions of resilience (Davoudi et al., 2012)			
Engineering resilience	- Technical measures - Spatial measures, - Creating redundancy / abundance		

Ecological resilience		- Discouragement of vulnerable land-use, - Adjustment of functions - instalment of insurance / recovery funds	
Evolutionary resilience			General: - Risk communication - Awareness raising private stakeholder: - through brochures - public campaigns - early education in school. Public stakeholder: - brochures - public campaigns
Characteristics of resilience (Restemeyer et al. 2015)	Robustness	Adaptability	Transformability

Table 1: Resilience framework, based on Restemeyer et al. (2015) & Davoudi et al. (2012).

2.6 Conceptual framework

In short, The Social-ecological system (SES) is relevant because this research will look from the perspective of the actors in the area at how they (want to) tackle the drought problem. Desiccation and the imbalance in water availability is caused by the way in which society manages water and how people interact with the water system, which in turn falls within the social domain of the system. This way, SES may promote desiccation through its design, which increases the systems vulnerability. In this context, desiccation requires recognition of the imbalance in the SES to be able to create the ability to transform (transformability) and adaptation (adaptability) of land use per location so that this better suits the circumstances. This requires acceptance in the social sense in order to be able to implement changes (transformability). Droughts are the climatological events that a system needs to be able to handle and become resilient too. These events increase the uncertainty for a system when it comes to retaining its balance. It is not possible to prevent these events from happening, but merely to become more robust as a system and to adapt in a physical sense to handle these situations. Robustness and adaptability are connected to the ecological or physical side of the system, and transformability as well as adaptability are part of the social side of the system. How this is implemented ultimately leads to a certain approach that can be reduced to a certain definition of Resilience.

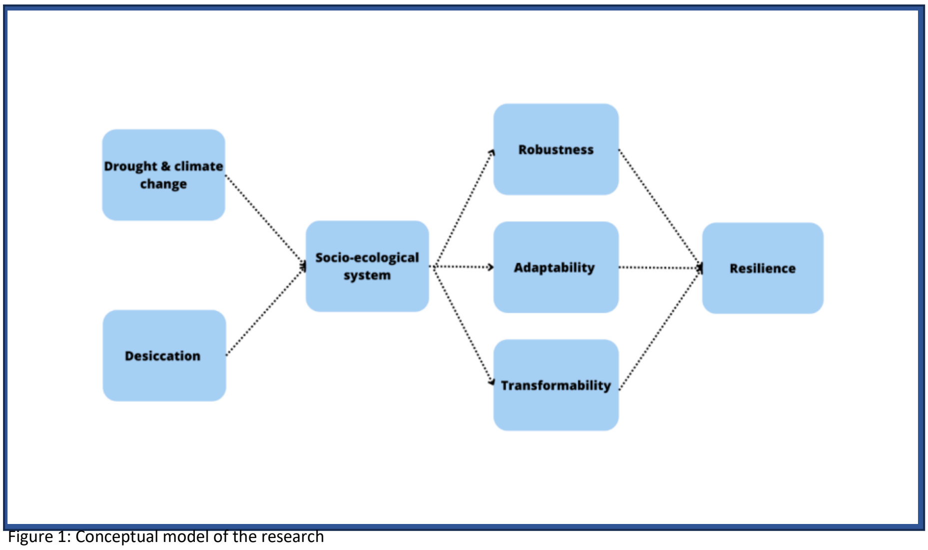


Figure 1: Conceptual model of the research

3. Research method

In this chapter, the methodology for this research is explained. First, the research strategy and design is elaborated on and the case study is introduced including a historical analysis. After that, the data collection and analysis methods are set out. The methodological section ends with ethical considerations and limitations.

3.1 Research strategy and design

The goal of this research is to gain knowledge about the concept of resilience and to be able to answer the research question: How can spatial resilience in the context of drought be achieved? This research relies on qualitative research methods. This was deemed most suitable for this topic, as qualitative research provides a more in-depth understanding of experiences and perspectives, which are important to understand the complexity surrounding an abstract concept like resilience (Hennink et al., 2020). Qualitative approaches are particularly convenient for gaining a more profound comprehension of the effects on the issue being researched, which is perceived to be a beneficial trait for looking at the complexity of a subject. Qualitative research provides the possibility to investigate a phenomenon while taking into account its surrounding context and intricate complexities (Hennink et al., 2020). In this research a mix of qualitative research methods have been used consisting of a literature review, semi-structured interviews and policy document analysis.

This blend of qualitative research has been selected due to its capacity to generate more comprehensive information about the examined issue (Clifford et al., 2016). To answer the first and second sub-questions a literature review was conducted. To answer the third and fourth sub-question, in-depth semi-structured interviews were conducted.

3.2 Case study introduction

In order to analyse how spatial resilience in the context of drought can be achieved, a single case study approach was chosen. According to Baxter & Jack (2008), Case studies serve to provide elaboration on the reasoning ("why") and the implementation process ("how") of projects, with a specific emphasis on explanatory research. This research approach is therefore well-suited to the main research question since both the 'why' , in why is there a problem and the 'how' to solve this are included.

To gain more concrete knowledge about real life situations about spatial resilience in the context of drought, the case area of water authority De Dommel has been selected for this research. A case study approach refers to the detailed examination of a specific social system, or in this case socio-ecological system (Clifford et al., 2010). In this case more specific even about a socio-ecological system.

The case study approach is suitable for this research because it helps to concrete contextual knowledge about the subject, which is important for research into sociological phenomena, such as personal values and perceptions (Flyvbjerg, 2006; McCombes, 2019). Furthermore, case studies prove beneficial when there exists a restricted timeframe within which the research must be conducted. (McCombes, 2019). However, although the single-case study is acknowledged as a valuable approach, it should be taken into account that they are likely to provide weaker evidence than a multiple-case study (Yin, 2017). That is why it is important to treat the results from a case study carefully concerning generalization (Clifford et al., 2010). Due to case studies being carried out within a particular environment, uncertainty can emerge regarding the adequacy of identifying universal and predictive theories. (Harvey, 1969). Therefore, although this study hopefully makes interesting findings for similar areas, the results cannot be generalized. However, even though formal generalization may not be feasible as a result of a single case, due to the in-depth information that a single case can yield, findings can serve as a valuable example that can be linked to situations beyond the scope of the study (Flyvbjerg, 2006).

3.2.1 Case selection

Internationally, the Netherlands is well-known for its expertise and extensive heritage in water management. (Restemeyer et al., 2018). However, much of its focus is still regarded to an excess of water, the safety issues this entails, and functionalities surrounding water such as transport and freshwater reserves. And only to a lesser extent, its increasingly more common counterpart, a shortage of water.

On the 3rd of August 2022 the Dutch minister of Infrastructure and water management issued a letter on the state of the drought problem (Rijksoverheid, 2022). In here it is mentioned that the problem of drought is becoming more of an issue for the entire Netherlands, but that the drought manifests itself particularly in the South, East and Southwest of the Netherlands at the elevated sandy soils. Considering the increased irregularities due to climate change and increasing drought events, the elevated sandy soils of the Netherlands provide valuable case for investigating the possibilities for achieving spatial resilience in the context of drought. As a result of these droughts, waterboards in these areas instituted temporal, as well as seasonal returning structural groundwater withdrawal restrictions (De Dommel, 2023b). The case area of waterboard the Dommel, which has no external input of water through larger rivers (see figure 1), relies solely on the precipitation that falls in the area, making it even more vulnerable to water shortages. As this research focuses on the water cycle as the unit of analysis, this area provides a clearer picture due to it being mainly precipitation and drought. The relevance of the case study area considering the drought issues is also evident from the several reports and policy plans to tackle the issue (depicted in 4.1), as well as the presence of an existing test site with innovation lanes (InnoA58) and a submitted EU Proposal (INTERREG NWE) on improving the imbalance of the water cycle by creating a climate adaptive water hub.

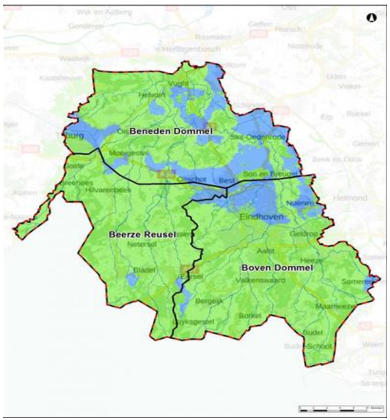
Figure 1: Water streams of the case area depicted in different colours.

When investigating a case it is important to clearly define the case. This can be achieved by defining theoretical, temporal and spatial boundaries for the research. This way it is clearly defined what is inside the scope of research and what is excluded (Baxter & Jack, 2008; Yin, 2017). The theoretical framework of chapter 2 describes the theoretical boundaries of the research, while the spatial boundary is selected on the basis of the outlines of water Authority de Dommel. Temporally wise, the research is limited to the data collection period, which lasted from February 2023 to June 2023, the data collected however, predates the start of this research and in many cases has a time frame that lasts until after the end date of this research (see documents in table 3) . Within this timeframe there is typology of measures that contribute to (policy) goals. Some measures work immediately and others take longer to contribute. Within this timeframe this research focusses on the policy plans and goals that are present and contribute to becoming more resilient in the face of droughts. It is important to mention that this research does not take measurements on the current state of resilience, nor how the resilience changes in this timeframe. So, this research examines viewpoints regarding various measures, aiming to construct an understanding of these measures and the perceived extent of their contribution to resilience.

3.2.2 Case description & historical analysis

For this research the case area of water authority De Dommel has been selected and more specifically the south of the Beneden Dommel and the north of the Beerze Reusel area. The water management of this area is under the authority of a water authority located in the province of Brabant, situated in the South of the Netherlands (see figures 2 & 3). Although water management falls under the water board, in addition to that, there are several other stakeholders in the area that also have certain authority over water related practices that influence the SES in its functioning.

Because the area consists of the water authority demarcation and it is the executive body for water, it is important to mention what a water authority is and how it functions.
A water board is governed by two bodies: the general board and the executive board. The general board, consisting of representatives of stakeholders such as residents, farmers and companies, sets the policy and supervises its implementation by the executive board. The executive board, led by the dike warden, is responsible for preparing and implementing the policy. The dike warden, comparable to a mayor, is the chairman of the water board and has a seat and voting rights in the executive board (Rijksoverheid, 2023).



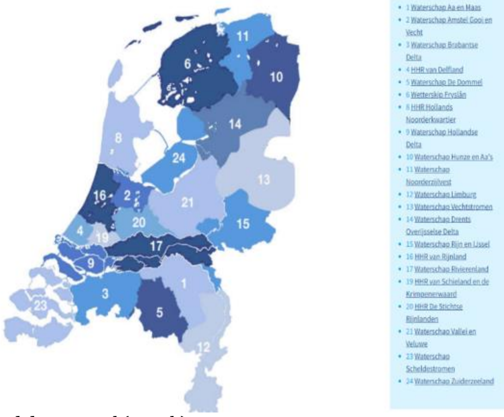


Figure 2: waterboard boundaries. Bron: Waterboard de Dommel (2023b)
Figure 3: Waterboards of NL, number 5 De Dommel : gemalen.nl

In water board elections, members of the general board, who represent the general interest, are directly elected by residents of the water board. Not only national political parties participate, but also parties with a focus on water issues. In addition, representatives of farmers and nature managers are appointed by their respective organizations because these organizations are both assured of participation with 2 seats through secured seats. The term of office for these board members is four years, with the exception of those appointed on behalf of interest groups (Prodemos, 2023).

Within the water authority area there are several local streams of which the namesake of the water board, de Dommel, is the largest. This stream originates across the border in Belgium and flows into the river Meuse after it connects with the river de Aa at the city of 's-Hertogenbosch (Waterschap de Dommel, 2023a). The dependency on local streams and therefore regional rainfall makes the area more vulnerable to droughts (Waterschap de Dommel, 2023b). According to Philip et al. (2020), droughts will become more common in the Netherlands' inland areas, including a substantial portion of the Dutch Meuse River basin, as a result of climate change. major urban areas in the proximity, besides 's-Hertogenbosch, are the cities of Eindhoven and Tilburg, of which Eindhoven falls entirely inside the boundaries of the Waterboard. Physical geography wise the area contains mainly sandy soils with a transition zone to the north of sand and clay (see figure 4). Within this area of mostly sandy soils there is quite some difference in height between south and north, relative to a lot of other Dutch areas, with a drop of 30 meters between the origin of the Dommel and its confluence in the Maas (waterschap De Dommel 2023b). In total the area consists of approximately 900.000 inhabitants distributed over 31 full and partial municipalities.

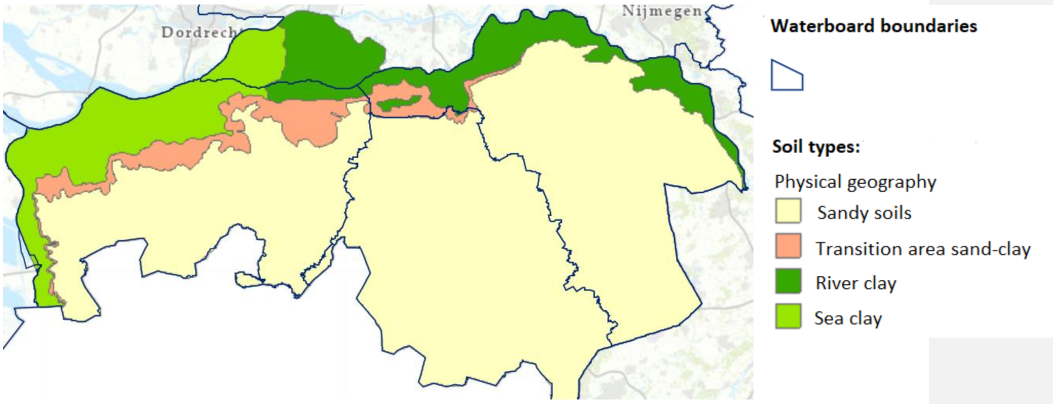


Figure 4: Kaartbank (2023) – Noord-Brabant showing the different soil types in the area.

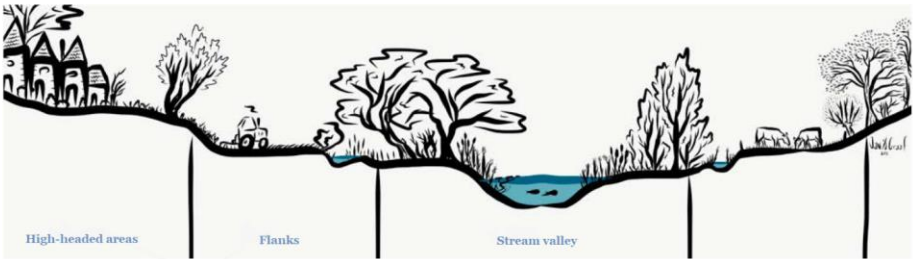


Figure 5: Cross-section of the landscape with the high-headed areas, the flanks and the stream valley. Retrieved from: (Waterschap de Dommel, 2022)

The area has been subdivided into 3 zones by the water board (see figure, 5).

High-headed areas are mainly dry areas where rainwater infiltrates easily and the distance from the upwelling areas is greatest. They act like a sponge for the area.

Flanks are used to indicate the areas between the high sandy soils and the lower stream valleys. These transitional areas have a complex water management that requires a lot of attention and offer numerous possibilities.

The stream valleys have an ecological function in the system and serve as a collection area for excess water from built-up and rural areas. They are located low in the landscape where groundwater flows.

In the area, the flanks take up the largest part (47%), followed by the high heads (37%) and the stream valleys are the smallest in size, at 16% (Waterschap de Dommel, 2023c ; Waterschap de Dommel, 2022)

As already touched upon briefly in earlier sections, decisions and interventions made in the past have influenced how Dutch drought governance and management is arranged today and shaped the way we now operate the (water) system. From the late nineteenth century onwards, and even more significantly after the Second World War, technological innovation, rising prosperity, and a belief in manufacturability brought about a profound transformation. In this period, the circumstances of the time and a vision of Sicco Mansholt and his motto of "never hunger again" to overcome the food shortages of the time, created an emphasis on enhanced water systems and rapid drainage of surplus water to enable higher food production (Mansholtcampus, 2023). During this period, large land consolidation projects were carried out, and the water system was mainly constructed to fulfil agrohydrological demands, of which nature was the main sufferer (Brockhoff et al., 2022). Previous to the land consolidation, the abundant water also regularly caused problems, which made striving for drainage at that time logical.

In the reconstruction period, between the 1950s and 1960s, the province underwent a radical transformation. Extremely rapid demographic and economic growth took place during this period. New residential areas were built to accommodate this growth, while industry moved to industrial estates. At the same time, (mainly) small-scale agriculture in the outlying area was being prepared for a larger-scale future. As a result, Brabant and the water board area of the Dommel have now been set up as an: "efficient 'dewatering machine' with more than 40,000 km of waterways." (Advies Commissie Droogte, 2022 p20.) The structurally lower groundwater levels this resulted in, accompanied with the uncertainties related to changes in weather patterns and increasing demand, created an imbalance between the available freshwater and amount necessary for the usage of a variety of land-use functions. Enabling land-use in the stream valley through drainage, thus leading to more vulnerability in the different areas (stream valley, flanks, high-headed) in terms of drought. Of which nature is the main sufferer.

3.3 Data collection techniques

3.3.1 Literature Review

For this research a literature scan of the most relevant information has been done to dive deeper in the different definitions of resilience and acquire measures and indicators for the concept of resilience. This literature search has been conducted by looking at English (peer reviewed) journals and the databases of SmartCat and Google Scholar were used in the search for academic publications. Initial key words where resilience, drought & water governance and desiccation. The relevant literature acquired was subsequently also scanned to add other relevant literature. This can be referred to as manual snowballing when sampling is executed through referrals (Frey, 2018).

3.3.2 Policy documents

Policy documents have been analysed to answer the fifth sub-question and give additional information on sub-questions two to four. To construct an overview of the policy plans concerning drought issues and the ideas to become more prepared for the uncertainties from climate extremes, a content analysis of 13 documents (see table 3) was performed. This list is based on their contribution to water and drought governance, or the advisory value it has on the drought issues in the case study area. This does not include a complete list of all existing documents, but rather the most relevant selection for this research into resilience related to drought in the case area. Documents in-directly related to the subject, such as potentially relevant climate adaptation measures and approaches where not included for this reason.

Level	Governmental	Year	Knowledge institute	Year
National	-Omgevingswet 2024 - - Kamerbrief over rol Water en Bodem bij ruimtelijke ordening -Deltaplan zoetwater 2022 – 2027- Nederland beter weerbaar tegen droogte - Nederland beter weerbaar tegen droogte	-2024 -2022 -2022 -2019	- Droogte in zandgebieden van Zuid-, Midden- en Oost-Nederland	-2021
Regional	- Regionaal water en bodem programma 2022 – 2027 - Zonder Water geen Later -Grondwaterconvenant 2021 - 2027 -Water in Brabant 2030: Wateragenda voor de Brabantse omgevingsvisie	-2022 -2022 -2021 -2017		
Local	-Elke druppel telt voor 10 -Bijlage: Bouwstenen (Elke druppel telt voor 10) -Water als basis voor een toekomstbestendige leefomgeving Waterbeheerprogramma-2022-2027 - Actieplan Leven-de-Dommel (2019-2022)	-2023 -2023 -2022 -2019		

Table 3 : policy documents & knowledge reports

3.3.3 Semi-structured interviews

To answer the third and fourth sub-question, in-depth semi-structured interviews were conducted. Here stakeholders helped to gain more insights on resilience in the case study area and provided some additional contextual information. Semi-structured interviews are quite useful in this regard as they are based on a standardized list of questions to ensure continuity in the interviews. At the same time, it allows for a degree of flexibility, whereby the interviewee can discuss unanticipated topics that were perhaps outside the researcher's initial scope. In this manner, it can offer detailed and more valuable insights into the subject, as it reveals underlying reasons not attainable through quantitative research (Clifford et al., 2010; Clifford et al., 2016l). The theoretical framework of chapter 2 formed the basis for the interview guide that was used for the interviews and the code tree used for analysing the data.

For the selection of participants for the interviews two main requirements had to be met. First of all, it was required that the participant had a stake in the area in some form or manner related to watermanagement. Secondly the participant needed to play a role in the drought issue. Therefore, it was deemed necessary to include the most drought-affected sectors: drinking water, nature, and agriculture. The relevance of these and other participants in the drought story also becomes apparent, among other things, from the direct or indirect involvement in the Grondwaterconvenant (2021), that has been drawn up to look in cooperation for solutions the water issues. Following these requirements several participants were contacted via e-mail or phone and through these interviews some new candidates were found. This is a so-called snowball sampling method that helps to acquire additional participants through referrals from those already interviewed. (Robinson, 2014). These participants represent perspectives and stakes within the drought issue. However, this does not mean that there were no other participants that met the requirements, but for practical reasons and time constraints the number of participants has been kept at twelve participants. An overview of participants that contributed to the semi-structured interviews is visible in table 5. All the participants were active in the south of the Netherlands and speak Dutch; Therefore, all the interviews were conducted in Dutch. In consultation with the interview participants - interviews were recorded, and the recordings were transcribed. In one instance it was preferred to have no recording and therefore handwritten notes have been made.

Met opmerkingen [wl1]: In hoeveel gevallen? Wees exact, niet zo vaag….

Table: 5 Overview of participants in in-depth semi-structured interviews

Interview number	Participants	Date of interview	Abbreviation
Participant 1	Water Authority De Dommel	31-03-2023	P1
Participant 2	Municipality of Oirschot	21-04-2023	P2
Participant 3	Water Authority De Dommel	24-04-2023	P3
Participant 4	Farmer	08-05-2023	P4
Participant 5	Water Authority De Dommel	08-05-2023	P5
Participant 6	Knowledge institute	10-05-2023	P6
Participant 7	Rijkswaterstaat	10-05-2023	P7
Participant 8	Spokesman area cooperative	18-05-2023	P8
Participant 9	Arborist	22-05-2023	P9
Participant 10	Province of Brabant	24-05-2023	P10
Participant 11	Brabant Water	05-06-2023	P11
Participant 12	Brabantslandschap	08-06-2023	P12

For conducting the interviews an interview guideline has been used (See Appendix A – interview guideline). This guideline was used in order to collect comparable data from all the participants, to the extent possible. In the interview guideline there is a general set of questions asked in each interview, on which was elaborated on depending on the interviewee.

3.3.4 Data analysis

During the phase where the significance of processes is discerned, the challenge lies in presenting a compelling causal explanation for the purported cause-effect relationship, thereby reducing the likelihood of alternative explanations. To discern this in the gathered data for this research, deductive, as well as indicative coding has been used. Deductive coding is a top-down approach where you start with a set of predetermined codes and then find excerpts that fit those codes. Inductive coding on the other hand is a bottom-up approach where you start with no codes and develops codes as you analyse the dataset. The deductive and inductive codes were categorized and displayed in a code tree (see Appendix B). The gathered data was analysed and coded through using the coding program Atlas.ti.

The analysis was done following the next steps:

- First all the data files were exported into Atlas.ti
- Secondly deductive codes where created on the basis of the concepts referred to in the theoretical framework
- Additionally two sub folders were created to divide the created deductive codes from the yet to be created inductive codes.
- Subsequently , while analysing the files, the deductive codes were assigned and indicative coding was made while sifting through the data files. The quotations connected to these codes were then automatically located to the relevant folder.

3.3.5 Ethical considerations and limitations

In order to enhance the credibility of research, it is crucial for researchers to take into account a range of ethical considerations (Clifford et al., 2010). To ensure the comprehensive evaluation of relevant ethical aspects, the Ethical Checklist provided by the Research Ethics Committee of the Faculty of Spatial Sciences was consulted. By following established ethical guidelines and frameworks, researchers can uphold the integrity of their work and contribute to the overall trustworthiness of the research findings.

Therefore, each of the participants was approached via e-mail or telephone and received questions regarding their consent for the interview. The interview was then conducted as agreed and the gathered data from the interviews is kept safely and is exclusively used for the purposes of this study. The stakeholders that have been interviewed can be divided into certain sectors, but automatically mean that they are a fair representation for the sector or institution. The group that is included in this research is simply too small for this.

Berger (2015), emphasizes the need for researchers to acknowledge their position's potential influence on the

research objective. He further notes that biases, beliefs, and personal experiences can lead to alternative interpretations of the results.
Therefore, it is important to mention that this research is conducted by an Environmental & infrastructure planning master student that participated in an internship at Rijkswaterstaat. This internship provided connections that have been used in conduction the research. Within the internship the researcher was also an observer in the Climate adaptive waterhub Interreg project (CAWH). These positions might influence the background of the researcher, and therefore , influences how questions are formulated, data is filtered, and conclusions are drawn.

4. Findings and analysis

This chapter presents the findings of this research. The initial aim of this research was to examine how resilience could be achieved in the context of drought. In order to find answers to this, first the relevant national, regional and local policies are introduced, as well as knowledge reports. Later on, the goals and accompanied measures to achieve resilience will be described in this chapter, together with information from the semi-structured stakeholder interviews.
The results will be presented following the structure of the theoretical framework and the concepts that were introduced there, starting with the problem drought & desiccation, followed by the context of a SES and ending with the resilience and its characteristics and definitions.

4.1 What do policy documents say about resilience and measures for resilience related to drought?

The planning system for water policy in the Netherlands is derived from the European legislation of the Water Framework Directive (WFD). This policy consists of a National Water Program, Regional Water Programs at provincial level and water management programs at water board level. (Provincie Noord-Brabant, 2022)

Water management in the Netherlands is organized among different levels of government. The national government holds responsibility for developing the national policy framework and strategic goals for water management. At the regional level, the province is responsible for translating this into a regional policy framework and for strategic goals at regional level, particularly focusing on strategic groundwater policies (*regional water & soil program*). Furthermore, the province acts as the competent authority for evaluating and possibly granting permits for industrial water withdrawals exceeding 150,000 m3 per year. They also hold authority over groundwater extraction for public drinking water supply. The central government is the manager for the main water system, and is responsible for operational water management of the main water system. They set the necessary conditions to achieve strategic water management objectives, determine specific measures, and implement them effectively. On the other hand, the water board acts as the competent authority for various aspects such as drainage, water supply, industrial extraction below 150,000 m3 per year, agricultural extraction, and other extraction related to construction activities and soil remediation, described in the water management program of the waterboard. Further, the municipalities are assigned to several tasks in water management, primarily centred around rainwater and groundwater care obligations. Additionally, managing the sewer system is a significant responsibility for the municipality, which is regulated under the Environmental Management Act.

National Documents

Environment and Planning Act (Omgevingswet) (Ministerie van infrastructuur en milieu, 2016).

The Environment and Planning Act is a comprehensive legislation in the Netherlands that outlines regulations for the protection and utilization of the physical environment. Its main objective is to simplify and merge the rules governing spatial development throughout the country, from multiple to just one law. By enacting this Act, the government aims to ease the facilitation of projects. These legal changes might benefit the ability to transform a system and enable new choices that can strengthen the resilience of the system. Additionally, the act seeks to establish stronger connections between various projects and activities related to spatial planning, environment and nature, sustainable development, and different regions. This integration between sectors is also considered as an important aspect that contributes to resilience building, since interconnectedness is a characteristic of a SES. Thus easing the integration could potentially benefit the possibility to transform and adapt.

National Delta plan zoetwater 2022 -2027 (Nationaal Delta programma zoetwater, 2021).

The Delta Program on Freshwater Supply has an overarching goal of ensuring the Netherlands' resilience to water shortages by 2050. This involves maintaining and promoting a healthy and balanced (ground)water system, safeguarding essential uses, and employing freshwater efficiently and economically. The soil and water system in the plan are set as leading concepts for spatial developments. Making the soil and water leading in spatial development is an essential change in perspective and considered necessary in tackling the drought issue in becoming more resilient as a system.

Final report on 'drought policy table' (Ministerie van Infrastructuur en Waterstaat, 2019).

The drought policy table report has been drawn up as a reaction to the drought of 2018 and 2019 and the major social and economic consequences this entailed. In the final report, the Policy Table on Drought made 46 recommendations to be better prepared for future periods of drought. These recommendations have been assigned to individual parties and regular projects, such as the Delta Programme, Integrated River Management, the Drinking Water Policy Document and environmental visions of provinces and municipalities. the main measures that emerge from this are:

Retain water better, which will increase the robustness of a system to withstand a drought event. Climate-proof land and water use. This measure or goal is more general and actually goes back to what it means to be resilient. Because if a system is adapted to the climate in its land and water use, it can be considered as resilient in the climate that is present.

Future-proof drinking water supply, is one of the sectors with a demand for fresh water that needs to be incorporated into the balance. Although generally formulated, it is important to make sure that drinking water supply is organized in such a way that it allows the system in its totality to be resilient. Regional and supra-regional cooperation, improves the ability of governments to bring certain regulations more in line with the intended objectives and ensures a smoother transition of responsibilities between levels. This helps to realize resilience, because in some cases the measures for a less vulnerable system are clear, but the implementation is still lacking.
Drought knowledge development in order to increase the effectiveness of measures and create more awareness on the subject.
Working integrally between sectors is important because, bringing different sectors together is thought to be a key factor in boosting resilience. This is because the interconnected nature is a defining feature of a Social-Ecological System (SES).

Report 'Drought in Sandy areas of south middle and eastern Netherlands' (van den Eertwegh et al, 2021).

This report was drawn up on the basis of a drought study that took place between the beginning of 2019 and the autumn of 2021. The report analyses the severity of drought, the effects of water abstraction, dewatering and drainage, and the consequences of measures during periods of drought for nature and agriculture. It also provides insight into possible structural measures to be more resistant to drought and its negative effects.

The focus of this analysis is mainly on agriculture and nature in the rural areas of the sandy soils in the south, central and east of the Netherlands. The main contributions of this report for this research are the development of knowledge as well as measures that help in becoming more resilient. Various measures are mentioned for this purpose such as creating a lager water buffer in the soil and waterbodies by retaining more water, as well as through reducing extraction. The supply of water via surface water and the acceptance and adaptation of water shortages are also mentioned in this regard. An important facet in this is that increasing the supply should go together with measurements measures in the dewatering system, because if the replenished groundwater is afterwards drained away again, the net replenishment is considered ineffective. This is relevant for the case study because Brabant is also described as a drainage machine

In summary,
The legal changes might ease the ability to transform a system and enable new choices that can strengthen the resilience of the system. The integration between sectors that is intended with this act could contribute to resilience building, since interconnectedness is a characteristic of a SES.
The soil and water system becoming leading concepts for spatial developments can bring about a change in perspective that could benefit resilience.
Important measures are: to Retain water better, Climate-proof land and water use,
Future-proof drinking water supply, Regional and supra-regional cooperation,
Drought knowledge development , Working integrally between sectors

With these measures an important facet in this is inclusion of measures on the dewatering system to make the net replenishment effective.

Regional Documents

Grondwater convenant 2021 -2027 (Grondwaterconvenant, 2021).

The groundwater covenant is a joint initiative in which various parties, including water boards, nature organisations, drinking water companies, industry and the province, make agreements to restore and monitor the groundwater balance in Brabant. The purpose of this covenant is to work together to restore the groundwater balance in Brabant. Some general goals are set in the Convenant in the form an aim to raise the average spring groundwater level by 10 cm in 2027 compared to the reference year 2002 in the lower, level-controlled and in some cases already wet parts of Brabant and by at least 35 cm in the higher-lying infiltration areas.

This would increase the buffer capacity of the available fresh water and therefore increase the robustness of the area. Another important aspect of the Convenant is the cooperation and communication that is established by means of this agreement. These aspects could increase the ability to transform if necessary and allows for broader implementation of adjustments through cooperation between stakeholders.

Wateragenda voor de Brabantse omgevingsvisie (Water in Brabant 2030, 2017).

In response to the Environmental Act, the province of North Brabant has drawn up an Environmental Vision. As a starting point for the dialogue about this vision, the water agenda 'Water in Brabant 2030' has been developed by the four water boards, Brabant Water and the province of North Brabant. No specific measures are suggested here , but a general goal to work together towards a robust and climate-proof future is proposed. 'Water in Brabant 2030' paints a picture of the desired situation of the water in Brabant around 2030 and identifies the ambition, urgencies and steps that must be taken in the coming years to achieve this. The document is not an end product, but forms the starting point for further discussions about a climate-robust and future-proof water system in Brabant. In that sense, this document is more one for raising awareness and looking for a common goal.

Regionaal water en bodem programma 2022 – 2027 (Provincie Noord-Brabant, 2022).

The regional water and soil program (RWP) of the province of Noord-Brabant gives substance to the ambition of the province to work on sufficient water, clean water, safe water, a vital soil and climate adaptation in the coming years. The RWP is a concrete elaboration and addition to the Brabant Environmental Vision in the field of water and vital soil.

The Environmental Vision forms the overarching and leading framework for the RWP and aims to work towards a safe and healthy living environment with good environmental quality. Clean and sufficient water, vital soil, flood risk management and climate adaptation contribute to improving this environmental quality.

The RWP sets interim goals for 2027 that are necessary to ultimately achieve the ambition for 2050. Principles suggested here to achieve this are:

- - Improve deep replenishment (rivers)
- - Improving shallow replenishment Brabant-wide:
- Replenish groundwater resources, retain water, optimize dewatering levels and promote infiltration.
- - Reduce groundwater extraction from drinking water and industry
- - Retention of water and sustainable spatial planning of areas
- Accepting (temporarily) higher water levels and retaining water instead of rapid drainage improves the soil (sponge effect) and responds to flooding.
- - Reducing irrigation withdrawals from agriculture
- - Saving water and reducing low-quality use of drinking water and industry
- - Integrated approach to flooding, drought and WFD
- - Waterways in good order

Zonder water geen later. Naar een omslag in het (grond)waterbeheer in Noord-Brabant (Advies Commissie Droogte, 2022)

In the advisory report of the independent Drought Advisory Committee, this committee advises on tackling the drought problem and working towards a drought-resilient system. Here, the Brabant groundwater partners are told about the necessary structural adjustments in the (ground)water system, (ground)water management and (ground)water use from an integral and long-term perspective on drought. This is done on the basis of highlighting the problem, the task, the strategy deemed necessary and the measures to achieve a drought-resilient province. In order to, through joint responsibility, realize a (ground) water-rich and resilient water system for Brabant in 2040. Goals and measures that are suggested here are:

1. Groundwater levels throughout the province can be raised structurally by:
(1) retaining more water, causing groundwater levels to rise substantially, (2) extract up to 100 million m3 less groundwater per year and (3) Infiltrate 100 to 150 million m3 more per year.
2. Buffer zones will be set up around the entire Brabant Nature Network (NNB) and the stream system in which restrictions will be imposed on the extraction of groundwater.
3. Making nature as a water-requiring 'function' equal to the other water users in North Brabant.
4. Creating several types of sources per drinking water company, in order to meet the growth in drinking water demand and to reduce the dependence on drinking water supplies for groundwater.
5. A strong price incentive for both large users and consumers to achieve the reduction of drinking water consumption.
6. Encouraging circular working with water.
7. For all new housing and urbanization plans to be developed, the (finiteness of) the availability of drinking water and freshwater scarcity must be taken into account in the design. This could well coincide with the new environmental law.
8. A reconsideration of the current cooperation model in order to accelerate and scale up the agreements already made
9. Raising awareness among stakeholders.

Local Documents

Actieplan-Leven-de-Dommel: Water management program 2019-2022 (Waterschap de Dommel, 2019).

Is the previous water management program of water board de Dommel that lasted until 2022. However, the goals mentioned in here have an ongoing character and can therefore still be relevant for the progress towards a more resilient or robust water management. The ambition of the action plan is "*realizing a robust, resilient and smartly controllable water system*".
To achieve this, it is deemed necessary to have measures at all levels of the local water system, by "*working together with our area partners on a water system that is better able to withstand a shock in dry and wet periods*". Considered important in this is an integrated approach to prevent or minimize both flooding and water shortage.

The main priorities mentioned to achieve this are:

1. Retaining water and smart management in rural areas. (Increases robustness)
2. Increasing the sponge effect in built-up areas. (Increases robustness)
3. Working together with area partners on the right use in the right place. (Increases transformability/adaptability)
4. Risk-based mowing management: draw up a concrete mowing plan for each waterway with a clear goal, associated message and advice to third parties. (Increases robustness)
5. Extraction of groundwater and surface water (including for irrigation) (Increases robustness)
6. Water distribution: research into options for choices and improvement of water management in times of flooding and drought. (Increases transformability)
7. Let the bottom act as a sponge for higher retention capacity. (Increases robustness)

Water Management Program 2022-2027 (Waterschap de Dommel, 2022)

Is the follow-up to the above water management program and partly builds on the path that has been taken there and also feels the need to achieve a water transition in order to become future-proof as a water authority.

With the Water Management Program 2022-2027, De Dommel Water Board starts the water transition; on the way to a future-proof water management in 2050. This is deemed to require a culture change in action that will be set in motion over the next 6 years. Like the previous water management programme, the aim is not to act sectoral, but to act integrally in the search for solutions. The mission stated here is to pursuit “a future-proof living environment, for which a future-proof water management is a necessary condition. With a water management that is robust, agile and in balance with the environment.”

The three main aspirations are:

1: Holding every drop and infiltrating where it falls

2: Functions adapt to the soil and water system

3: What is clean must stay clean

Every drop counts for 10: Water Transition, Implementation Strategy: & Appendix Building Blocks
(Waterschap de Dommel, 2023c & 2023d)

The intended objective in this policy document is "a water management that is robust and flexible and in balance with nature and the environment." The implementation strategy for sufficient water consists of ten building blocks, which when added together have an effect on the water system, the appropriate land use and the organization of the water board. All ten building blocks are important here and are interrelated. The building blocks cannot be viewed separately from each other and must be implemented in collaboration because “the task is large and urgent and the building blocks do not have an effect at the same place and at the same time.” The buildings blocks separately focus on different aspects such as becoming more robust and increasing the adaptability or transformability, but in combination and over time result in a more resilient system. Here, too, the focus is on working towards the intended goal in an integrated manner through cooperation with the stakeholders in the area.

Further relevant information about the mentioned documents will be elaborated on in the rest of the results section in conjunction with other insights from the interviews.

4.2 Different perspectives on drought and desiccation

4.3.1 Drought

Drought manifests itself in different ways for different sectors and stakeholders or the focus is placed on different consequences in each. However, drought is in all cases seen as something that has a negative impact on what the stakeholder stands for or has to deal with.
For the water board, which is closely involved as the body responsible for the smaller surface waters and shallow groundwater layers, drought means several things. For example, they observe that problems arise for nature objectives on land in times of persistent drought. These are developments such as. *(P1) “Streams that run dry, forests that are destroyed by the drought "*
With the message from ecologists that tackling the nitrogen problem is pointless for nature if something is not also done about the drought problem. Water targets from the Water Framework Directive are also jeopardized by longer periods of drought, including for flow speed and water quality. *(P5)“This also means that it is more difficult for the water board to meet water targets from the Water Framework Directive.”* Although these consequences mainly emerge in times of drought, they also have to do with structural desiccation.

For drinking water companies, drought mainly means a higher demand for drinking water, which means that the pumping installations and pipes used to extract and purify water from the ground are running at maximum capacity. This creates a situation in which the water supply can partly stagnate during peak hours. *(P11)*

" This can be seen as a kind of highway where there is plenty of space at night, but where it can be very tight during rush hour and it can stagnate a bit."
Although this is not so much related to the water system and is more of a technical issue, it does indicate that in the periods when the pressure on the water system is already high, demand from society also increases.

The agricultural sector mainly pointed out that drought leads to a lot of investments in preventing drought damage. This is partly due to the installation of irrigation equipment that runs on electrically or on fuel and therefore costs extra money, both in the purchase of equipment and the energy source of keeping it running. This is done using a pipe system deep into the ground, from which groundwater is then pumped up to irrigate the land. In case of persistent drought, crops can suffer from drought damage in the form of dried-out crops, but stagnation in the growth process can also occur. To get higher yields, it is therefore sometimes necessary to irrigate the land. This is not directly related to the drying out of crops, but without intervention it would lead to lower yields. *(P4) " If we can't irrigate, you will have less yields and perhaps also a lower quality crop.*
It was also indicated that they did not experience any damage from drought, however irrigation measures were required for this. The need for irrigation due to the drying out of crops during drought is being noticed in a broader sense in the agricultural sector. Just like other stakeholders, it is recognized that this has consequences for the groundwater level. *(P4)" It dries up not only with me, but with everyone in agriculture and if everyone starts irrigating and everyone pumps up groundwater, then of course we will also have problems there, because the groundwater level will drop."*
However, the emphasis is still mainly on an excess of water rather than a shortage of it, because this also entails certain consequences. For example, large machines can only be used on the land later without smearing the soil and thus disturbing the capillary effect of the soil. There are also crops that cannot handle too high water levels, because they are causing rot. The complicated and complex nature of occasionally too much water and the insidious nature of structurally decreasing groundwater levels and longer periods of drought is also experienced in practice in this way.

The municipality mentioned that nature in the city suffers during periods of prolonged drought, as a result of which more and more water has to be given, for example to keep trees upright. This despite the often deep and extensive root systems these trees have. This development was also mentioned by the province and could therefore serve as an indicator for the falling groundwater levels. *(P10)" The striking thing is that it is now really clear that old trees and avenues of trees are dying, which have sometimes been in one place for 200 to 300 years."* Although this mainly occurs during prolonged drought, it is also a consequence of desiccation.

Rijkswaterstaat reported that soil subsidence and the resulting subsidence of roads is the greatest risk that occurs in times of drought in the case study area. The chance of this is currently only low because the main road network is robust against these developments. *(P7)" In general, studies show that our main road network is robust when it comes to sensitivity to settlement when it comes to drought."* As an asset manager of the major roads in the area, this is one of the greater risks for the range of tasks, but other consequences are also noted, such as agricultural damage, settlement damage and damage to nature.

Drought has many consequences for nature. *(P12) "Several things will occur in Nature Reserves, such as streams that discharge less water as soon as there is little supply" "The same is the case with fens and ponds. These can dry up while this did not happen in the past or dry up earlier in the year."* Vegetation adapted to swampy conditions disappear or die out, which in turn affects certain insect species associated with it. *(P12) "That is also something that plays a lot, that we lose certain special nature types because we notice year after year that it is too dry too quickly."* This usually does not happen in 1 year, but due to persistent desiccation, an area does lose specific species.
Drought is seen here as a climatological phenomenon that you can only anticipate, while desiccation is a result of human actions and interventions in the landscape and water system. *(P12) " Desiccation is, so to speak, a choice, a choice we have made by designing our landscape as it is today."*
This view was shared by other stakeholders who added that drought is an uncertainty that you have to anticipate to. *(P10)"You can only prepare or be resilient to the consequences of drought. Because you can't prevent it from raining and not raining for a long time, but you can perhaps prevent it from affecting you too much."*

What emerges in a broader sense is that for many stakeholders, drought means that they have to take (ad-hoc) measures. While according to van den Eertwegh et al. (2021), it has been established that ad hoc interventions in water management just before or during dry weather hardly have the intended effect. This way of acting has to do with the way in which the Social-ecological system is set up and the desiccation that this results in. That is why the next section will elaborate on desiccation and how this is experienced. The research shows that to reduce the impact of drought on agriculture, nature and the water system, structural measures are needed right down to the capillaries of the water system (van den Eertwegh et al, 2021).

4.3.2 Desiccation

Desiccation has a strong correlation with how the SES is structured. In contrast to drought, desiccation is seen here as a result of human intervention in the landscape and water system. In these situations, water is pumped away early and discharged to the sea to facilitate various landscape functions, resulting in structurally lower

groundwater levels. In contrast to drought, desiccation is seen as a structural thing; *(P10) " Desiccation is a structural problem." " You could prevent desiccation, but drought basically not."*
Yet little action was taken against the drought events until 5 years ago and many stakeholders experienced the drought mainly as a nuisance that mainly affected nature. *(P10)" That was a problem of nature for a long time and apart from the hardcore nature lovers, water boards found it difficult, farmers found it difficult, administrators found it difficult, because high levels in the spring mean that farmers cannot use their machines on the land."* As with drought, desiccation comes to the fore in other ways and one sector/perspective is more likely to have negative consequences or is less able to limit these negative consequences.
The underlying indicator of desiccation is generally a lowering of the groundwater level, but this manifests itself in different ways for stakeholders. *(P5) "For agriculture, this means that often it needs to resort to irrigation because there is insufficient ground and rainwater available for crops, which actually exacerbates the problem even further."*
The more frequent recourse to irrigation of crops can therefore be seen as an indicator of desiccation, because structurally lower water levels mean that the groundwater is more quickly out of reach of the crops' roots.
Another indicator of desiccation, in more urban areas, is the subsidence of houses.
(P10) "What you also hear, but that has more to do with desiccation than drought, but people link it together, that is the sinking of houses. This is also simply due to structurally low groundwater levels"

But by far the most consequences of desiccation can be seen in nature.
For example, one of the indicators of desiccation that emerges from a nature perspective is that: (P5) "*streams are less water-carrying and have less seepage*.".
This seepage occurs because groundwater that has infiltrated into the soil in higher areas is pushed up again under high pressure in lower-lying areas, particularly in the sandy soils of Brabant at the transition to clay. *(P12) "This seepage pressure has completely disappeared in very large parts of Brabant, which was there until the 1950s - 1960s - 1970s, because the groundwater level has dropped."'*
A consequence of this is that certain species, such as in 4.3.1 are dying during extended periods of drought. *(P10)" What we've seen in 5 dry years is that that shift, or near extinction, that's not going to double, but 3 or 5 times. That goes exponentially. "*
These plants that become extinct can then also be seen as a broader indicator, because they indicate that the ecosystem around this vegetation, such as insects and other flora and fauna, is no longer able to survive in those conditions. Certain ecosystems disappear from areas and are succeeded by others. It is therefore not about individual vegetation, but about what this means for the whole that surrounds it.
(P10) " Not because of the orchids in themselves, but because this means that an entire ecosystem can function."
"*It's not about that crested newt and it's not about the orchids, but it's about the fact that you need that diversity to be able to continue living in the Netherlands as we are used to."*

The current system suffers from a lack of sufficient groundwater reserves and a rapid exhaustion of the buffer capacity after wet winter periods. This affects nature mainly, but also various other sectors in society are increasingly affected. For example: ''*Social sectors such as the drinking water industry (with reduced security of supply), agriculture (with loss of income due to crop damage), the built environment (with costs for repairing subsiding houses), the transport sector and shipping (with damage due to lower load factors, for example), and the cultural heritage (with damage to historic estates and gardens) increasingly negative consequences*."
(Advies Commissie Droogte, 2022 p34.)

For the experienced consequences for nature, a comparison was made with how nitrogen affects nature. For example, just like water-loving species and species that thrive better in other conditions, you also have nitrogen-loving species and nitrogen-hating species. If a change in the system then takes place, there will be a shift in these species in an area that reduces biodiversity. It has also been noted in other areas that desiccation has negative consequences.

(P12) " In all nature areas in Brabant, Brabant landscape suffers from desiccation. This desiccation takes place in several places in the landscape, which means for the nature perspective. *(P12)" Structurally, therefore, it is actually not in order in terms of water management."* As a result, desiccation is very high on the agenda at Brabantslandschap as one of the nature and environmental problems to be tackled.

The water board and the province already have a far-reaching and clear vision of what a resilient system should look like in their water programs. But despite this clear vision the distance between what is written in policy documents and the organizations working in the field is still perceived as very large (Advies Commissie Droogte, 2022).

In summary, drought is seen here as a climatological phenomenon to which it is possible to anticipate that manifests its self in different ways with different stakeholders, but has a negative impact in each case. Nonetheless, the emphasis is still mainly on an excess of water rather than a shortage of it. The main focus is still on (ad-hoc) measures, while ad hoc interventions in water management just before or during dry weather hardly have the intended effect. Desiccation on the other hand, is a result of human actions and interventions in the landscape and water system.
this leads to more frequent recourse to irrigation of crops, because structurally lower water levels mean that the groundwater is more quickly out of reach of the crops' roots and subsidence of houses in urban areas. As well as ecosystems that die off.

To counter this trend in structural groundwater depletion, there are also structural changes necessary in the way in which the socio-ecological system is set up in order to prevent the desiccation that the current functioning of the SES results in.

4.3 The socio-ecological aspect of the drought issue

Building on section 4.2, this section will dive deeper into the socio-ecological aspect of the drought issue and attempts to highlight the link between the functioning of the SES and the resulting desiccation.

The socio-ecological system that we have today has emerged through various factors. Within this context, only a few elements dominate. One prominent aspect is the pursuit of efficiency and yield maximization in land-use, particularly in agriculture, which arose after World War II. Another partially related component that emerges in other factors as well is the belief in a controllable world. (P3) "A*fter the 2nd world war and the famine that took place in it, a kind of mantra crept in in which we shouted, never again and everything we do we do in the context of the food supply. That was a bit of the start of the flight that led to enormous increases in scale in agriculture and the design of the water system was adjusted to this"*
The development of certain areas and the maximization of efficiency through landscape modifications, such as creating ditches and draining excessively wet areas, enabled land-use functions that were previously not possible in those regions. To achieve maximum yields for land use, it was necessary to design the land for optimal efficiency. Hence, during the spring, water is drained through drainage systems and ditches to prepare the land for use during the coming growing season. (P4*) "It is often too wet for too long in the spring, then we can't get on the land to work the soil, so we're too late to plant or sow our crops, and then we have a problem getting it off the land in time in the fall."*
Not draining excessively wet areas prevents the land from being cultivated with large machines in the spring when the groundwater level is still high, as they would sink into the marshy ground. The more natural course of events for these areas does not provide the right conditions at the right time. *(P4)"Yes, you can also do it naturally, but then it won't happen at times when we think it's important for our agriculture."*
For agriculture, the goal is to have water drained as quickly as possible. Therefore, the landscape in Brabant is designed to facilitate rapid water drainage through ditches and other drainage methods to achieve low water levels. Modifying the landscape was thus necessary to pursue higher yields and aligned with the objectives set after World War II.

Another influencing factor is that land prices in the Netherlands are relatively high, which compels landowners to generate high levels of production. The downside of this is that, in order to maintain suitable water management for various forms of land-use, regardless of the location, groundwater needs to be constantly drained and pumped back in times of drought. This has led to a situation where the water system serves the purpose of accommodating land use functions. *(P11)"Our water system has constantly adapted to the functions."*

This has ultimately resulted in a water system in Brabant that could be described as a drainage machine. *(P1) " The whole system in Brabant, including the land consolidation, everything was always aimed at maximum water discharge, the lowest possible level in the spring." "80% of the precipitation that falls is directly discharged by the water boards to the sea. That is not the fault of the water boards, that was simply their task and that is how it was set up".* The system was primarily designed for maximizing land-use efficiency and yields, however, lowering water levels did not only serve the purpose of reclaiming land for agriculture but also allowed for housing in certain areas. The consequence of this during periods of drought is that, due to the additional petrification of the surface, the water is drained too quickly, rendering this water unavailable for use.
(P1)" So we now have a water system that drains a lot and that was really necessary in the past, because Brabant has traditionally been a swamp area, which has been made suitable for agriculture and housing " " But now you see that all the water we extract is just gone and if we don't make it in the summer then we have nothing."
This way of organizing the SES is now showing its adverse effects during longer periods of drought. Additionally, also making areas suitable for the road infrastructure has an impact on the desiccation of an area by pumping water out of recessed locations. Infrastructure that is made possible in areas due to artificially lowered water levels, contributes to the depletion of groundwater levels in their surrounding areas as well.

(P7) "Some of those sunken structures have a very large leakage effect. In the management area of the Dommel water board, for example, you have a sunken location at Best. There is a sunken location of 2 kilometres. There, all year round, so even in a very dry summer, groundwater constantly leaks into it, which we pump out, which does not flow directly, but eventually just flows to the sea."

In addition, petrification in mainly urban areas has a negative impact on the infiltration capacity of an area due to rainwater washing away from roofs and other petrified parts via the sewerage system. *(P10)" In urban areas, for example, you could collect more of it and not discharge it via the sewer. "* In these situations, rainwater enters the sea via the sewage system and then via drainage systems such as canals and rivers. Due to this way of acting, we are currently dealing with a water system that also drains the water that that precipitates in these areas at an accelerated rate. *(P10) 'As a result, a lot of (rain)water is drained off more quickly and does not get the chance to penetrate the soil and replenish the groundwater."*
Many of the interventions in the landscape and the manner of water management mentioned above, also entail that the water system reacts very directly to climatological events such as peak showers of rain.

The system in Brabant is also set up in such a way that almost all drinking water is extracted from groundwater. *(P11)"In Brabant and also the high sandy soils, the drinking water there mainly comes from the groundwater."* This also means that groundwater extraction for drinking water influences groundwater levels. However, this effect is not direct, because the water is extracted from long, slow, deeper systems of water between 30 and 300 meters below ground level, which also comes from Germany and Belgium via water that is between 100 and 10,000 years old. There are actually 2 systems within groundwater levels: a shallow system that reacts quickly and a deeper system with clay layers in between. These layers do have an effect on each other, but this is not a 1 on 1 effect. (P11) "*It is not the case that if we pump up less groundwater that there will suddenly be water in the streams". "It is true however that, because we pump up groundwater, you do lower the groundwater level in some places all year round*".

While wetter areas were made suitable via drainage for various functions, of which agriculture was one of the largest, higher areas that were perhaps not so suitable for drought-sensitive land-use could also be made suitable by means of groundwater pumps and irrigation systems and the discharged water could be compensated in the spring with groundwater abstractions during drier periods. This system of drainage in wet periods and irrigation with groundwater in dry periods illustrates the philosophy of the makeable world. This manufacturability through drainage and irrigation with groundwater enables a landowner to arrange the conditions for each plot in such a way that it matches the desired land-use. *(P9) " We have set it up in such a way that it can be arranged per plot. Because we can drain water separately for each plot and supply water separately."*

For the reasons stated in this section, the way in which the SES functions has a strong correlation with desiccation. In this way, actions and developments in the SES lead to a situation where groundwater levels fall structurally. *(p3)"That you build up shortages more annually, year after year and that the deeper layers are also less water-carrying than they should be and that the groundwater sinks into them, where this did not happen before" (P5) "We see in Brabant that we are structurally using up the groundwater supply. So, every year more goes out than goes in".* While the aim is that this is more in balance.

The way the system is set up has therefore led to a situation where the balance of water supply and demand in space and time is out of balance in times of persistent drought. Year round there is enough water, there is only an imbalance of supply and demand over time. *(P11) "It is a question of space and time. Actually, there is enough water, just not in the right place at the right time."*

In summary:
Key aspects of the way the SES functions are the post-World War II emphasis on efficiency and maximizing yields in land use, particularly in agriculture and the belief in the controllable or creatable world. These factors, together with the influence of other water affecting stakeholders, have led to the development of a drainage-intensive system in Brabant. The manufacturability through drainage and irrigation with groundwater enables a landowner to arrange the conditions for each plot in such a way that it matches the desired land-use. However, this way of organizing the SES is now showing its adverse effects during longer periods of drought.

The reasons for the problems that arise in times of drought thus have a structural component that can be found in the way the socio-ecological system functions. It is not so much a shortage of water between the input and output during a year that causes the imbalance, but the way in which this water is managed, in general terms, as well as at parcel level. This in turn, is related to the groundwater requirements of certain land-use functions.

To achieve resilience in periods of drought, physical changes in the landscape, as well as sociological changes will be necessary. Due to the interconnectedness of the actors and physical area, as well as the complexity involved and the need for both sociological as physical changes, the perspective of the SES is seen as a good angle to address the imbalance.

4.4 Findings about the components of resilience

4.4.1 Robustness

The robustness measures that have been mentioned in the interviews, were included in policy documents, or in both, are divided here into several overarching themes. These measures differ in whether they contribute to making the total system or the parcel level more robust.

Increase of water retention

One of the things the water board is looking into is retaining the water for longer periods of time in certain ways and use smart management in the rural area: in the main system and in the capillaries. This was already part of the water program of Waterschap de Dommel (2019) until up to 2022 and this aim has also been set in the water management program up to 2027. Here the goal is, with the help of technical interventions, to raise the water in the water-courses managed by the water board, to increase the (ground)water levels as high as possible all year round. *"Unless forecast models (surface water-groundwater weather models) show that the risk of flooding is unacceptable as a result (we do not comply with legal standards)."* (Waterschap de Dommel, 2022. p51.). *(P3) "One is indeed that you connect water over time, so holding it when it falls so you can use it when you need it. But that is of course a huge challenge spatially".* However, discharging less or not at all via B and C watercourses, to make sure that the water stays in the area for a longer period and can replenish the groundwater, also has an impact on its surroundings which leads to additional (land-use) adjustments . Nonetheless, increasing (ground) water levels is an objective from the water board that can increase robustness (Waterschap de Dommel, 2023d). B and c watercourses here are a fine mesh of ditches that were once dug to make plots drier and prevents water nuisance. Because the goal for higher resilience calls for more robustness and with that more water retention a different direction for these *B- and C-waterways, such as damping, narrowing, shallowing ditches and trenches (dimensioning) and adjusting drainage."* Is deemed necessary (Waterschap de Dommel, 2023d p4.).

The (Drought Advisory Committees, 2022) also indicates in their advice that in order to achieve a drought-resilient (ground)water system, groundwater levels must be raised structurally throughout the province. To this end, retaining more water is mentioned as an important aspect to allow groundwater levels to rise substantially.

Slightly less specific, but in line with the water board's objectives, one of the most important changes is that for the whole of Brabant more emphasis must be placed on draining as little as possible and retaining as much water as possible. For example, there is a motto: "Every drop counts" of both the water board and the program of the province. The idea is that (rain) water is drained as little as possible and as much as possible is retained in the soil so that it can infiltrate into the groundwater. Higher areas will function as infiltration areas and lower areas will be structurally wetter. (Provincie Noord-Brabant, 2022). The agricultural sector also mentions things such as temporary retention by means of technical interventions such as placing dams. *(P4)" You can arrange all sorts of things, you can ensure that you have weirs on the left and right, that you can influence the water per lot, that it retains the water for part of the area and that it does not immediately drain to a lower area."*
Ideas are also mentioned about pumping back a surplus of water from lower-lying areas back to higher areas to which it is still useful. *(P4) "In a lower area I have a water problem, actually I should have a way to pump the water from the lower area back to the higher area to irrigate or let it into a drainage system"*
This is mentioned as a way of retaining water that could work for farmers, in which they can also keep their plots dry. This is still theoretical, but it remains important for these land-use functions that the water can be directed to the function of the land.

The water board is also actively involved in spatial measures such as reintroducing and optimizing current and historical streams in the area. *(P10)"What we do there is restore streams and raise the soil. Leave a narrower and shallower container for low drains with a somewhat wider bed for when there are higher drains."* This ensures a more constant flow in the middle with the possibility of more retention in the bed. When restoring streams and creeks, it is important here not only to focus on the stream itself, but also on creating a wider valley in which the stream can meander freely and where wet conditions are possible. That the landscape not only consists of the stream, but is also made more sloping, so that natural processes are given more space.
(P10) "We often measure this in how many kilometres of stream you have recovered."

This is a more general goal here, and therefore how this will exactly develop, including landscape design, is not yet entirely clear. An indication of the improvement of buffer capacity in this respect could be measuring the groundwater levels.
(P10) " A lot of attention is paid to those higher levels, but everyone still finds that difficult, because we have said that this must be done, but now it must also be done. But you could simply measure how much surface area we used at higher levels for this." In the ditches and waterways that are maintained by third parties, incentives are given to retain as much water as possible*(P5) "With weirs, raising culverts, closing culverts, etc. to ensure that they cooperate where possible in retaining the water as much as possible."* These kinds of measures, that are already being applied, are seen as a positive contribution to making the system more robust because water is provided a longer period of time to travel through the area and thus has more time to infiltrate.

This way of acting does have exceptions for certain specific situations if existing land-use functions are compromised: *(P5) "An important part of this is still the agriculture that is still there. If there is a threat of damage or flooding, the level may be lowered."*
"Also, if there is a threat of damage to other functions (buildings, vulnerable nature) we adjust the gauges.

however, this is getting later and later in the year. *(P5) "The moment we say, now the farmers should really be able to go on the land and those dams should be lowered, that was already from February. The board now wants to keep April 1 as the date where possible to lower the weirs, to keep the water level high as long as possible."* This also stems from the water board's responsibility to weigh up the various interests and to meet all interests as well as possible. *(P5) "We have to look at what is the function of that waterway there and what is the most important thing that waterway has to do there and then we have to ensure that we have that water available for as long as possible."*
The water board must also take other aspects of the water system and the surrounding regulations into account in its ambitions to retain water for a longer period in the area. This also contributes to a more integrated approach to water management. *(P5) "The flow objectives (WFD) also apply to a very large part of our own watercourse, so you don't always want to hold on to that, but also that the stream has to flow".*

The increased retention period of water in an area is also seen as an important measure for other stakeholders. The measures that contribute to limiting the discharge speed would improve the water retention capacity of an area and thus make it more robust against dry periods. This consists of performing spatial measures to restore previous changes in the landscape related to drainage. *(P12)" Water courses are dug too deep or over dimensioned which is not necessary, which we can repair. So, it doesn't have to be as bad as it was ever made, so you have to take that profit back anyway." " An area has in fact lost its robustness due to all kinds of human interventions, by draining all the water immediately, making it sensitive to desiccation and other influences. You can go a long way by rectifying mistakes made in the past with today's knowledge, giving it back some of its robustness."*
Measuring groundwater levels throughout the year is a very tangible indicator that is often used to test the effectiveness of the measures that have been taken. Later, after observing the groundwater levels as an indicator for the measures, vegetation is also examined as an indicator for the success of the measures for a more resilient system. This second indicator is only a much more difficult one because it is something that often reacts much more slowly and therefore cannot be used as an indicator after a year to measure whether measures have worked. This is a matter of long-term analyses in which trends are recognized, but cannot be determined absolutely. (P12) "*The examples are there, that after 10 years you restore an area and see species return*"

Rijkswaterstaat, as asset manager of major road infrastructure and surrounding areas, pursues a policy on allowing road water to infiltrate. *(P7)" We already have the policy that we want it to infiltrate, so that's our preference, that's in our framework for road runoff. What you see is also the most effective way to purify it".* This option works for infiltration if road water flows into the area around it, but if this is not the case and it ends up in the sewer system, there is still potential to use it more usefully.
(P7) "As soon as a road makes a bend, it is a kind of banked bends and the water flows to the inner verge and enters the sewer system and then the question is what happens to that water. If it goes directly towards a ditch, then you will have contaminants in your ditch, but will it go via a wadi or will it go to the sewer system, so really sewage treatment, there is still something to be gained there." In addition to this water that ends up in the sewer, which happens at the sunken locations mentioned in 4.3.1, are also a possible source of rainwater that could be used to increase the water buffer in an area. This water currently ends up in the sea via a detour, but could also make a major contribution to the robustness of the area. (P7) *Can't you use that water? Those are such large quantities, that is much more interesting than the direct run-off road water, in my opinion.*"
Much of the rainwater now flows off pavements and surfaces, comes together in different places and is drained away. Partially this water is collected via the mixed sewer system and unnecessarily treated in sewage treatment plants. The other part is discharged through separate sewers and sewer overflows at an accelerated rate via surface water (Waterschap de Dommel, 2023d).

Municipalities focus on different ways to retain water.
(P2) " Holding on is simply very important and we are very busy with that everywhere, with the construction of infrastructure and wadis and the like. " In addition, weirs are also being installed here, also in collaboration, to keep the water in the area longer. Measures taken here try to be as flexible as possible so that they respond to the uncertainty of the drought problem. *(P2) "Where possible, we try to work with wadis and aboveground drainage. You can actually go in all directions with that in the future. It is the easiest to maintain and costs the least money, but it is not always applied as a matter of course."*

Reduction of evaporation and water demand (less extraction)
The people from the agricultural sector who were interviewed for this study mainly looked at becoming more robust and more resistant to drought by taking measures at parcel level. The perspective of the crops and the plot and measures that would make this more resilient is quite central here. Mostly technical drought resistance methods were looked at, by creating things next to the existing land use, so that these functions remain resistant to drought events in their current form. A controllable system that can be controlled by the owner himself is seen as ideal. *(P4) " I think you have to go to an optimal system, that I can go on my land when I want and that I can also leave when I want. So in the spring I have to be able to go on the land to work it, to fertilize it and sow and plant it. And in the autumn I have to be able to go on the land to get the crop from the land. And in between, my crop must be able to grow well. "*

In order to be more resistant to the drought, farmers often dug groundwater wells to absorb these short periods of precipitation. This is then used to irrigate or irrigate in some other way. Irrigation therefore takes place at certain

times, such as at night to prevent evaporation as much as possible. This action against the desiccation of crops is increasingly under threat, because longer periods without precipitation increase the pressure on the groundwater system from, among other things, agriculture due to these withdrawals.
It was also indicated in the interviews that drilling a groundwater well on one's own initiative is no longer allowed. *(P4) " At first everyone could just drill a well and then extract water, but that is of course subject to rules and that is no longer possible everywhere. "* For the individual land owner, this reduces the robustness at plot level, because they are not always able to supply water. The idea behind this is therefore not to facilitate individual plots, but to make the system as a whole more robust by structurally raising the groundwater level in conjunction with other measures.
In its implementation strategy (every drop counts), the water board has set the goal of reducing withdrawals. This concerns the extraction of shallow to medium-deep groundwater, in particular by agricultural entrepreneurs and private individuals. To achieve a situation in which the water system is leading in the decision making on the type of land-use and the amount of groundwater that is extracted for these functions. For irrigation, this means Brabant-wide a reduced extraction of 20-40 million m3/year in a dry year compared to the approximately 100 million m3/year that is currently extracted in a dry year. That would mean about 5 -10 million m3/year for our water board. For small groundwater withdrawals, the goal for the time being is to prevent an increase and to develop the possibility of reducing certain uses.
This is already being done in part by means of standard withdrawal bans from April onwards for certain areas. *(P3) "In certain parts of our area, we have a standard withdrawal ban from April, where we have very vulnerable water systems. In other parts of the area, this will be set if the situation calls for it."*

In addition to the previously mentioned water retention, Advies commissie droogte (2022), in order to raise groundwater levels, also mentioned that up to 100 million m3 less groundwater will have to be extracted per year. Sub-irrigation can partly offer a solution here. This system was also mentioned in the interviews and can be explained as level-controlled drainage with the option of supplying water. This allows the rainwater to be retained as much as possible. The water comes from a canal and runs through drainage pipes into the plot and can be held there. This sub-irrigation system is also known as underground irrigation. Sub-irrigation then helps to maintain the groundwater level during drought. An additional advantage of this is that the plants develop their root system deeper into the soil. *(P4) "So that plant gets a stronger root system and is therefore more resilient. If you irrigate a plant very quickly from above, it will not have the urge to make roots that will search deeper for water. " It* is also able to drain water quickly when a peak shower occurs and thus allows more control.

within the agricultural stakeholders, this is a measure that is used to deal with water more efficiently and thus become more robust against drought, while at the same time water can also be drained and the system remains controllable. According to the interviewee, this makes the system more resilient because it better protects crops against drought. These measures are mainly technical interventions that affect a specific plot level and remain within the existing frameworks of land use functions.
In the eyes of the agricultural stakeholders in this study, a robust system still has a clear focus on the possibility of draining water. The drought aspect is starting to emerge in this, but mainly focuses on savings in irrigation and the ability to control.
(P4) "You have to provide good locks, good canals, good drainage methods, but you can close them if you want to retain water and if there is really too much water that you can open it quickly and drain it. A farmer must try to arrange this on his own land, but of course something must also be arranged in the area." The risk of flooding and damage to crops as a result of this still predominates in the approach to becoming robust against drought.

For forest and nature areas, forest conversion (from coniferous forest to deciduous forest) is a tried and tested measure, provided it is applied specifically to the target areas (Waterschap de Dommel, 2023d).
The contribution of this to becoming more resilient is the reduction of groundwater evaporation, but also the prevention of interception evaporation. Which is evaporation as a consequence of trees functioning as a barrier to for the rain and so prevention it from reaching the ground before it evaporates again.
(P10) "A much larger part is normal and that is what hydrologists call evaporation, but that is when it rains that the water is held back and does not even reach the ground. "

Supplying (Meuse) water and using residual flows (pumping water back into the system)

Supplying more (Meuse) water via the canals, in order to supplement groundwater shortages, is also a measure mentioned in the water management program and the building blocks of the water board de Dommel that can increase the water capacity in an area. However, this requires considerable efforts in the construction of new infrastructure and/or pumping up water to the higher parts of an area.
(Waterschap de Dommel, 2023d), (Waterschap de Dommel, 2022).
Other discussions also revealed that the use of residual water from other sectors for irrigation purposes is being considered. *(P10)" So there are all pilot projects to get that water back to the farmers so that they can irrigate their land. "* Yet, there are also doubts about the impact of some sources and whether less intensive options make a comparable contribution to the overall system. For example, the use of residual water from roads was also examined. *(P7) "The amount of water that flows off such a road, if you look at it and assess what you can do with it. For example, spraying farmland, then that is so little that it hardly makes any difference. And if you*

then look at what you would otherwise do with that water, infiltrating the soil, that is also a reservoir, making it available to the environment again at a certain point."

This way, the collection and retention of water on the one hand contributes to the prevention of groundwater withdrawals, but retention with the purpose of allowing water to infiltrate can also contribute to the replenishment of groundwater as kind of a reservoir. Side note for this measure is that, in order to use this building block in a meaningful way, a physical separation is necessary between the supply and removal systems. This is because of water quality and effectiveness. Meuse/canal water is not desirable in WFD streams. At the same time infiltration on the higher areas more suitable for groundwater replenishment, as there is more capacity. Additionally, separation of supply and discharge increases controllability (Waterschap de Dommel, 2023d).

Reduction of drinking water extraction

The drinking water company in the region, Brabant water, indicated that it often starts with a technical approach to the problem and looking at the effects of certain technical measures. Here they also look at additional sources to be able to meet the rising demand without further burdening the fresh groundwater. For this, brackish groundwater and seawater are considered as sources for drinking water and can be seen as a technical solution. *(P11) "These solutions require a lot of energy, a lot of technology and a lot of residuals, but as long as the water system is not in order, you have to do something."*
This search for alternatives is in line with the advice of the Drought Advisory Committees (2022), to realize multiple types of sources per drinking water company.
In this respect, it is also said that drinking water is so cheap that there is not really a financial incentive from the user to purchase it. *(P2) " Drinking water, for example, is very cheap, so there is not really a financial incentive for people yet. "* At the same time, due to the drought problems last year, situations arose in which a drinking water company no longer supplied water to certain industries. This creates a different consideration in determining the value of the water supplied to these companies. In situations of displacement, an industry may temporarily be unable to get water supplied and may therefore have to close. Including the costs for these kinds of things makes working circularly with water financially worthwhile, where this was not yet the case for the low prices of the water. *(P3) "If you are going to ask a company; what will it cost you on an annual basis if you have to close for 2 weeks every summer, because you no longer get water and convert it to a cubic meter of water. Then you get a completely different calculation. That is a new reality into which you will gradually find yourself."* So not looking at what it costs to filter the water, but what do the consequences of supply restrictions and, for example, low water levels in rivers during dry periods cost you on an annual basis and thus make circular use of water attractive.

Increasing infiltration capacity

It was also indicated that authorities such as municipalities could contribute by allowing more water to infiltrate in mainly urban areas by preventing petrification and by disconnecting buildings from the stormwater sewerage system. Subsidies have been set up by the municipality for disconnecting rainwater of houses from the sewage system, which are supplemented by the water board. This is called 'the decoupling doubler'. With this scheme, the water board doubles the contribution that the municipality gives to a citizen to disconnect the rainwater from the sewer (Waterschap de Dommel, 2022). This contributes to the resilience of the system because the risk of flooding is reduced and puts less pressure on the sewage treatment plants due separating the relatively clean (rain) water (Waterschap de Dommel, 2023d). The water, that would normally end up discharged via the sewage system, now is infiltrated through gardens directly or retained temporarily in rain barrels and infiltrated later on.

For the higher areas, allowing infiltration does not have the same effect as retention, because this water is not available as groundwater in those areas because the groundwater there is too deep. The infiltration benefits the area as a whole and creates more capacity in the stream valleys and flanks, So the retention is sometimes more effective at the heads if it can actually be held there. *(P1) "On the high sandy soils this is quite difficult, because water that you allow to infiltrate, also goes to lower grounds and streams and thus slowly leaves the area. So, retaining water is not possible everywhere if you have sandy soils. "*

(P2) " The berms next to the streets here have a very high infiltration capacity. If we don't do anything else there and we disconnect, it will be gone in no time. Then those trees that are there are of no use. So, to create a system around those trees that buffers the water in the foundation near those trees, the resilience of the greenery, those trees will improve again." In these respects, holding it for immediate use is more beneficial than letting it infiltrate. The high sandy soils have groundwater levels that are sitting too deep, so that infiltration of the water does not make these trees more resilient, but retention at location does. Because this prevents withdrawals, it also contributes to making the system more robust as a whole. This type of shelter is already being used in other urban areas. *(P1) " In Eindhoven, the city parks are also irrigated with water from the rainwater sewer. There are just underground buffers there and those tankers can just pump up from there."*
(P10) " In the urban area, however, it is examined how much surface of residential areas the rainwater is disconnected from the sewer. "

This way, a quantitative indicator can be given to the contribution that the measure makes for the increased buffer capacity, by allowing the water to infiltrate from the surface that is disconnecting. Instead of simply draining rainwater, that eventually ends up at the sewage treatment plant and is being discharged, it now infiltrates in the soil. Everything that ends up on the disconnected surface then contributes to increasing the groundwater capacity in the area. According to the Drought Advisory Committees (2022), in total, the measures need to achieve an increase in the infiltration capacity of 100 to 150 million m3 per year in order to bring the groundwater levels back to a level that will bring the system back towards a balance.

Soil improvement

Increasing organic matter content is also something mentioned as a measure that can be taken to strengthen the water storage capacity of the soil. This is also mentioned by the water board in its water programs and is described as a measure in the water covenant. The most decisiveness for this lies mainly with the agricultural sector, where this was the most prominent measure in the interviews. *(P4)" You should also look at your soil structure and try to raise the organic matter content a bit." This can be done by improving the soil structure. This can be done by growing more different crops, not only maize, potatoes and beets, but also a good green manure for once.*

An indicator for this measure that was indicated in the interview was the percentage of organic matter. *(P9) " Most of our soils are all above 4% organic matter and that actually retains water very well, in combination with those grass-clover lanes that we have between the trees, virtually no elements wash away with irrigation."*

Stimulating soil life for better structure and nutrient management can be achieved with nutrients such as compost, manure, crop residues and green manure, as well as less tillage. Stimulating soil life then contributes to resilience building by improving the sponge effect of the soil, so that the soil retains more water in the upper layer and allows more water to pass through to the deeper groundwater. At the same time, it also ensures that less water runs off superficially. This way it has a positive influence on becoming less vulnerable to drought events (Waterschap de Dommel, 2023d).

The tipping point for what is interesting as robustness measures to increase buffer capacity for existing land use functions instead of adapting more to the circumstances in some places, depends on the cost-benefit analysis and what we as a society consider important in this regard. Do we deem it important to be resilient against drought as a system, or are economic factors considered more important. It is more difficult to determine a physical demarcation of the area, as it depends on how far you are willing to intervene with technical measures. What is possible in this regard will also depend on finances *(P5) "So at the moment we are looking quite closely at what could all contribute, but at some point measures will also be reduced to cost-benefit analysis."*

Main measures	Instruments
Raise the water in the water-courses managed by the water board, with the help of technical interventions raise.	- Damping, narrowing, shallowing ditches and trenches (dimensioning) and adjusting drainage.
Placing more emphasis on draining as little as possible and retaining as much water as possible in the soil so that it can infiltrate into the groundwater.	-Placing dams, weirs and wadi's . - Pumping back a surplus of water from lower-lying areas back to higher areas to which it is still useful. - Using run-off water in a circular way. - Performing spatial measures to restore previous changes in the landscape related to drainage such as: reintroducing and optimizing current and historical streams in the area. - Re-dimension current b and c waterways and increasing the organic matter content of the soil.
Reduction of evaporation and water demand (less extractions/ withdrawals)	- Standard withdrawal bans from April onwards for certain areas. - Installing sub-irrigation systems, also known as underground irrigation. - Forest conversion (from coniferous forest to deciduous forest)
Supplying more (Meuse) water via the canals.	- Physical separation is necessary between the supply and removal systems
Reduction of drinking water consumption	- Additional sources of drinking water that do not burden the fresh groundwater such as brackish groundwater and seawater. - Circular water use
Increasing infiltration capacity	- Preventing petrification and by disconnecting buildings from the stormwater sewerage system, the instalment of rain barrels and other forms of retention at location.

4.4.2 Adaptability

The adaptability measures that have been mentioned in the interviews and that are included in policy documents are divided here into several overarching themes.

Prioritizing Water and Soil in Spatial Planning

To bring the land-use functions more in line with the environmental characteristics and a more natural water management of an area, there is policy at national level that aims to ensure that water and soil determine the landscape functions.
The so-called Building Block of the water board that connects to this is so-called groundwater-driven water-level management.
In this building block, it is not the function of land use that is decisive, but the (ground)water level. With this measure, the water board wants to keep water in the area for longer in order to raise the groundwater levels and then keep them at the same level (Waterschap de Dommel, 2023d).

Adapting land use functions to the water levels implies the acceptance that groundwater levels will rise in order to be more resilient to drought, while at the same time ensuring that the landscape is arranged in such a way that this makes sense for the location. This means that the function corresponds to the situation of a location, instead of the location characteristics having to be constantly adjusted in order to be able to perform the land use function. Adapting the land use functions to a more uniform set of water demand functions, that are better adapted to the environment, ensures that groundwater levels do not have to be discharged unnecessarily quickly for individual water needs of a location.
Adaptation measures ensure that if a drought event occurs, the damage will be less because you have adapted the function of the landscape to the possibility that this could happen.
(P5) "In the current policy we are still really based on facilitating the existing functions and that is something that we as the De Dommel water board also say: that is still the case at the moment, but it will not stay that way."

This change in behaviour and thinking is the so-called water transition, which is described in the water transition implementation strategy ' 'every drop counts for 10 ' .
Agreements have also been made in this direction in the groundwater covenant with tangible goals, to have the spring groundwater level 10 cm higher in 2027 compared to reference year 2002 in the lower, level-controlled and in some cases already wet parts of Brabant, up to at least 35 cm in the higher infiltration areas (Grondwaterconvenant, 2021).
At the same time, it is also indicated that without this measure of increasing water levels, the individual robustness measures to increase capacity will not be nearly as effective. There may be several measures to retain water, but if the land use functions do not allow or adapt to this higher level, much of this water will still leave the area prematurely. It is therefore important for a resilient system to implement all measures together. According to the document 'every drop counts for 10', the building blocks cannot be viewed separately from each other. *"We need all the building blocks because the task is large and urgent and the building blocks do not have an effect at the same place and at the same time."* (Waterschap de Dommel, 2023c p2.).
Restoring the balance in the system and providing the space to replenish groundwater supplies, as well as ensuring a land use that is drought-resilient, requires a series of measures as described in the robustness measures of 'retaining more water', 'extracting less water' and
replenishing more water. Providing these measures with the necessary space also requires an adjustment in land use and, just like with the water board, it is necessary to jointly implement them for a successful outcome (Advies commissie droogte, 2022).

Discouragement of vulnerable land-use

To provide the area with the ability to increase the water levels it is necessary that there is not too much accelerated discharge of side waters and drainage. To achieve this, one of the ideas is to review the drainage policy to reduce runoff and discourage negative impact. " Revision of drainage policy (Waterschap de Dommel, 2023d). In line with this, it is also stated that a change can be made within the Keur (the legal instrument of the water board) to discourage counterproductive action. " First we remove the negative incentives from (the Keur), which lead to more drainage. At the same time, we encourage activities by others that lead to less drainage." (Waterschap de Dommel, 2023d).

A change in crop choices, which are more resistant to drought, or crops that are better able to withstand wet conditions could then offer a solution. Abandoning unfavourable crops for the water & soil directed or function follows level vision could mean a lot of change for the individual farmer, but would make the system as a whole more resilient because it would allow a higher water level in low-lying areas and fewer withdrawals in higher areas. *(P12) "That means a lot to the individual farmer, but in those places individual interests stand in the way of a solution, so you have to find a good solution for that." "A way must therefore be found for this resilient situation to get the right crops in the right place in the landscape. So that the entire water system does not have to be changed for a crop."*

Crops that stand for a longer period of time are also mentioned for adapting the crops to the environmental characteristics and/or facilitating higher groundwater levels. *(P1) "We are now also looking at building materials.*

These are crops that you sow once for the next 30 years, so they are not crops that you sow again every year. Then you get crops that root deeper, you leave the soil alone more. Then you already get a completely different system."

The agricultural sector itself is also looking at cultivating less drought-sensitive crops and thus reducing the water demand. Organic or other cultivation that is better able to withstand periods of drought can be seen as an adjustment in land use if it does not require or requires less irrigation. In this situation, the possibility of drought is taken into account and instead of making the water-demanding crops more robust, the risk of damage is reduced, which means that the system can also be seen as more resilient. *(P4) "If you start with miscantus or with sun crown, you have a crop that can remain standing for 20 to 25 years, it will make a very extensive root system and those roots can also reach up to 2 to 3 meters deep, so they are not dependent on irrigation and can therefore better withstand the drought."*
It should be noted that this is currently only a limited part of the total crop. This is partly due to uncertainty about financial compensation and a certain demand. *(P4)" But I have to be able to harvest something from it every year, so that I can still get my balance."*
The realization of this change of crop is therefore currently still mainly in the research phase for both the governments and the farmers.

Adjustment of functions to become more in line with the surroundings

Discouraging vulnerable land use is in line with the main goal of raising water levels by adapting land use functions to the vision of function follows water level. Facilitating different land use functions that all have a different water demand leads to a system that requires a lot of control and is very technical. In some cases, the emphasis on preventing flooding and facilitating existing functions leads to a situation in which to prevent flooding on one parcel, the water level must be lowered in a larger area, resulting in possible drought damage in other parcels. *(P5) "Sometimes you have to lower that level in an entire area in order to ensure that they can harvest there for that one plot." "Perhaps indirectly 4 other plots have suffered drought damage as a result.""*

It is therefore the water board's vision to manage the area on the basis of the 'Function follows water level' principle. The Advies Commissies Droogte (2022 p60.), in their vision also mention that this also means a possible rearrangement of functions and land-use, and that "Not everything can be done everywhere". The regional water program has also included in one of their action principles that "not everything is possible everywhere". The land use follows what the water and soil system can handle. Not all user functions can take place everywhere in Brabant. Although it is not elaborated on exactly what it means, this principle seems to be very much in line with the general idea of function follows level vision. "*Some residual risks will have to be accepted; not all damage can be prevented and some functions are located in places that remain sensitive to flooding. Not everything is possible everywhere*." (Provincie Noord-Brabant, 2022 p52.).

In order to be able to raise the water levels, it is therefore beneficial if there is a general classification of land-use functions that is oriented to the area and the water management there. Adapting the current mosaic of land use functions, that are currently focused on different water demands, will ideally allow the land-use function to be more in line with the environmental characteristics, so that a more uniform water level can be achieved. *(P7) "The landscape should therefore not be too patchy or mosaic, because you cannot set the groundwater levels here on one piece and the groundwater levels there on an adjacent piece. You do need to have somewhat larger spatial areas that have the same land use."*

It is also no longer seen as robust or resilient to constantly have to control and steer the balance to a high degree. If you accept more water and adapt the land use to the situation prevailing in a certain area, then there is less need to adjust constantly and a system can handle more fluctuations itself and is therefore more resilient. *(P1)"If you say: we accept that a whole piece of grassland will go under water if it gets really bad, yes grass can withstand that, so then you are more into that robust model, in that resilience model."*
For this, the land-use function must be adapted in such a way that it fits in with the environment. *(P1) " You will see other crops coming, you will obtain drinking water in other places."*
This would mean that the current situation, where any land use function is possible everywhere regardless of location, and that the hydrological system is adapted to this on an individual level, should change to 1 where this is more in line with the environment.

Other sectors will also have to evaluate whether the function they perform somewhere fits the ecological situation there. Within the specific possibilities of Brabantslandschap, they look at what kinds of adjustments are possible and what they add. *(P12) "These units are then created by, for example, taking the measure to purchase an agricultural plot that is still present in that unit, which has a negative effect on the water management, in order to remove the disturbing factor from that area. Existing ditches are then filled in for that plot and that plot may then become wet grassland or forest."*
The measures that fall within one's own possibilities are simply not sufficient in this respect. A more integrated and environment-oriented approach to the drought problem is therefore also considered necessary by the nature sector. *(P12) " You can't solve nature problems in nature reserves, the environment also plays a role in this."*

Within these higher levels and the adaptation of the function to the environment, the idea is that by accepting a wetter situation in the stream valley, a multitude of surface in the middle part will end up in a situation that is therefore less sensitive to drought.

But there may also be opportunities for other sectors on the wetter soils. For example, pilots are being conducted to see what is possible here. *(P5) "For example, growing reed and then making building materials from it." Or "that nature management is also something that could be valued in that way."* However, there is still uncertainty about this from a business economic point of view and these developments are currently mainly taking place in niches.

To create opportunities for the areas that are becoming less attractive due to the changes in land-use functions, the downgrading of land around certain areas is being considered. *(P1) " That you should do less intensive agriculture around nature reserves and streams and make that land cheaper."* In order to realize this, an idea has been devised to make landscape land available that is less expensive, so that it also has to yield less. *(P1) "Landscape soil would then be a method for devaluing soil around vulnerable areas, so for example those natura 2000, those around high sandy soils and streams. This would mean that farmers there would have less expensive land, so they would also have to achieve less yield, so that they could work more extensively. They are working on the 'land bank' (grondbank) for that."*

What is currently being considered in the context of building decrees for new-build projects is that water is buffered at homes as standard, rainwater is disconnected and wadis are constructed in the area to collect and retain water. The idea here is that water retention is included in the spatial design. The urban land-use function is a complicated one in adapting to natural conditions. Changing residential functions to something that is more in line with the environmental characteristics and more natural water levels is quite impossible for existing situations. This is because it is very complicated and undesirable to move entire residential areas. For new construction projects it is possible to take the environmental characteristics into account, but for existing situations there are still certain obstacles that stand in the way of a function following water level situation or maximum infiltration.
For existing urban areas, it is then important to pursue the water & soil directive or function follows level vision as far as possible. *(P5) "If there is an urban area on a high head, you could at least strive for maximum infiltration of the water. For example, it is necessary to look from the 'water & soil management' perspective to what makes sense at that location and then strive for the maximum achievable."*

It is therefore essentially about taking into account what the area-specific circumstances are. These areas have, as mentioned in 3.2.2, been divided into 3 categories by the water board. The idea here is that, in areas characterized by elevated and arid conditions, one must consider the inherent high and dry nature of the environment. While such regions are suitable for constructing residential properties due to their reduced risk of flooding, they may not be optimal for cultivating water-intensive crops such as potatoes. Consequently, transitioning to alternative crop types becomes necessary in these circumstances. The flanks, serving as transitional zones, often exhibit favourable soil characteristics, making them ideal for implementing soil-based agriculture. By selecting agricultural crops that are well adapted to this specific soil and possess the capability to access available water, farmers can significantly reduce the need for irrigation. Conversely, in low-lying and moisture-rich regions, such as stream valleys and low-lying areas adjacent to nature reserves, it is essential to emphasize water retention strategies to manage the water resources effectively.

These measures are not only being taken to become more resistant to drought, but also to be able to cope with extremes such as peak showers. *(P10) "We not only want to be resistant to drought, but also to a peak of rain, which often occurs in a period of drought. "* In order to compensate for lost capacity due to the raising of the water levels, it is then necessary to make physical space to store water. A measure from the water board that links up with this is to design the relatively lowest-lying soils on the dry heads and flanks as an additional infiltration area.

On the one hand, this modifies the situation so that they can withstand drought better. At the same time, allowing higher water infiltration also ensures that the surrounding areas become more robust and therefore more resilient in an ecological sense. These lower parts also ensure that summer peak showers can be absorbed to prevent flooding in the lower areas, while the rainwater does not have to leave the system immediately. This retention of water in the lower parts of the highest elevated areas and flanks ensures that the amount of water is better distributed over the area and that not everything flows directly to the stream valley, which does not physically have the space for this. *(P1) "With that you build in more calmness, because that water is held for a while, it infiltrates and then later enters that stream. This way you build in delay and then you don't have that quickness either, because that also makes it difficult to steer."* The accelerated discharge as a collective causes a problem downstream in such situations, due to the speed of the system. The possibility of coping with extremes, by providing space, is also described as a goal in the regional water programme. When extreme situations occur such as peak showers, high water or prolonged drought, there is less or less serious nuisance or damage. In the future, the water and soil system will offer 'space' to cope with extreme situations such as peak showers, high water or prolonged drought in space and time (Provincie Noord-Brabant, 2022). It is difficult to give an unambiguous indicator for the added value of the measures mentioned in this section, but since the ultimate goal is to enable higher water levels, you could measure the success by means of the increased groundwater levels in an area.

Main measures	Instruments
Prioritizing Water and Soil in Spatial Planning	-Correspond the function to the situation of a location, instead of the location characteristics having to be constantly adjusted in order to be able to perform the land use function.
Discouragement of vulnerable land-use	-Revision of drainage policy - Remove the negative incentives from (the Keur) - Encourage activities by others that lead to less drainage. - Change to more suitable crop choices to the environment
A general classification of land-use functions that is oriented to the area and the water management there:	- A more integrated and environment-oriented approach to the drought problem - downgrading of land around certain areas were it is becoming less interesting due to water levels rises. - building decrees for new-build projects were water is buffered at homes as standard, rainwater is disconnected and wadis are constructed.
Ensure that summer peak showers can also be absorbed to prevent flooding in the lower areas	Coping with extremes, by designating certain areas as infiltration areas where water is able to accumulate

4.4.3 Transformability

The intended goal of allowing water and soil to guide spatial planning will require physical changes from many areas and therefore also from many stakeholders. The idea of function follows level will have consequences for stakeholders. The increases of groundwater and the resulting adjustments or changes in land use aimed at aligning with the environment will therefore not take place in the short term. *(P11) " This may sound easy, but it is actually very difficult, because we spent 20 years on all land consolidation and straightening ditches and removing everything as quickly as possible and now I think it will take another 20 years to arrange everything so that it fits the current reality again."* Achieving the physical goals and measures, which are classified under robustness and adaptability in this document, therefore depends, to a certain extent, on the ability of the system to change. Certainly, the measures under adaptability often depend on the transformability, because these measures cannot or can hardly be taken individually. To increase the possibility to change as a system, several measures are mentioned.

Dealing with financial aspects on the basis of solidarity

In a transition to a new vision, such as the 'function follows level' and 'water & soil steering', it is considered important that individuals who are deteriorating due to changes are nevertheless included in this. Seeking solidarity in this regard can contribute a lot to people's willingness to cooperate.
For example, the Advisory Committee on Drought (2022), states that it is important to include the involvement of farmers in a new land development round as they are, as a group with a large proportion of the landmass, an integral part of the solution. At the moment however, they do not seem to benefit directly, because the benefits end up elsewhere, such as sustainable energy, housing and climate adaptation. Looking at a way to balance this out will increase solidarity.

To increase the soil quality and the organic matter content in it, it would help to give more certainty to farmers so that they are able to take the step towards changing crop choices more quickly and at the same time achieve enough return to support the price of land. *(P4) " But yes, that all costs square meters and square meters are expensive in the Netherlands. Everyone should be able to earn some money in one way or another to pay for all their expenses."* This could be achieved by devaluing the land in stream valleys referred to in 4.4.2 for these purposes, so that the yield need not be as high. More certainty in the purchase of this crop can also be stimulated.

In order to realize the measures that adapt to a drier situation, or that contribute to a more resilient system in some other way, a certain return would therefore have to be achieved in order to recover the land costs. At the moment this is not yet experienced by farmers in this situation. *(P4)" We have to make sure that everyone in that chain can earn some money from it and then we can turn it into a nice system. But not if they fob off the farmer with a tip and walk away with the big profit themselves."*

Promoting adaptation in the urban environment is also indicated as something that has a positive effect. By making it financially attractive to disconnect homes from the sewerage system in terms of rainwater, through offering this free of charge and by providing guidance in the construction, the willingness to implement these changes increases. *(P2) " For example, something like disconnecting the homes of private individuals, we do that for free. All we need is the permission of the owners. That system works very well because normally we disconnect a street and then everyone just participates."*
In order to retain more rainwater and allow it to infiltrate in urban areas, subsidies are also made available to install rain barrels. This is done in collaboration with the water board. *(P5) "For example, the water board doubles the contribution that a municipality may give for disconnecting rainwater."*

In addition, the water board focuses on measures for companies such as: Incentive scheme for water conservation; Subsidies for, for example, soil moisture sensors and energy-saving techniques at company and household level. (Waterschap de Dommel, 2023d).

In order to achieve a reduction in drinking water consumption, the Advies commissie droogte (2022), deems it necessary to stimulate both large-scale users and consumers. A strong price incentive is suggested here in this respect. As an example, the graduated system based on the Flemish situation is mentioned here, whereby the basic need for drinking water continues to be offered for a low rate, but rises considerably above that for large-scale consumers. For large consumers in the province, it is proposed to apply a considerably higher basic rate for tap water, which will increase as more water is used. For consumers, a staggered rate system based on the Flemish is proposed, whereby a basic consumption is determined with a basic rate to provide for essential necessities of life. This emphasizes the importance of sensible water use and provides a clear incentive to use drinking water sparingly.

Another aspect under investigation, where prices could stimulate positive externalities, is the reduction of groundwater abstraction by pricing all types of water except rainwater. This is one of the measures mentioned that falls within the building blocks of the water board. " *Pricing of all types of water except rainwater*" (Waterschap de Dommel, 2023d p17.). For drinking water consumption, a comparison is made with the decrease in energy consumption after the price increases. This could then in a similar way create a more critical look at drinking water consumption by individuals and this way reduce the consumption of it. The water board itself has no decisive action in this regard. On the other hand, it is currently not the case that you pay less water board charges when you use less water, while that could also be an incentive, a financial incentive. *(P5) It could help enormously if people became much more aware of what kind of water they have available, what happens to it now and what they could do with it, either through a price incentive or something else."* For the drinking water company, drinking water is a product that is supplied with an obligation to supply. One change in this respect for Brabant water that is being looked at is looking at a shift in thinking. From unburdening people about the quality and availability of water to awareness of the value of drinking water and the question of whether drinking water quality is needed everywhere. It is important to create in-depth awareness about the why and what influences what. That is why it is important not only to focus on reducing drinking water, but also to provide the right alternatives.

Increasing awareness

Awareness is therefore seen in many policies as an important aspect to create more understanding and support for certain adjustments to make the system more resilient.
At the moment, general awareness is fairly low in terms of how the system as a whole works, what the influence of individual actions is on this and how that relates to the consequences in times of drought. That creates a leading group that is more involved in this. This leading group in the case study area, or rather the province of Brabant, are mainly those involved in the groundwater covenant. After the first really dry summer of 2018, which led to major drought problems due to the drying up of streams, the decrease in discharge and the rising water demand, the water covenant was set up to prevent these types of problems in the future. However, there is still a difference between those involved and the extent and sphere of influence in which they try to tackle the drought problem on their own initiative.

Farmers are involved with drought because they are confronted with drought in their business operations. Irrigation costs a lot of money for farmers due to generators and fuel. Due to the drought of recent years and the consequences for agriculture, understanding and support for measures has generally increased here.

Within the agricultural sector it is therefore recognized that the drought issue requires attention and that the current system has its limitations. *(P4) We are doing something that I don't think is really natural. And that can of course have a very nice effect in the short term, but in the long term it can sometimes backfire. Then we can better work on a system where we need as little as possible."* The focus is still on making adjustments at an individual level, so that one's own situation can be controlled. The search for a system with support is also regarded as important.

For private use of drinking water, it is also important to raise awareness that this leads to a switch to the use of rainwater instead of extraction from shallow groundwater. A switch from drinking water to shallow groundwater through private abstractions would have a more direct negative impact on the shallower groundwater due to the effect of the various soil layers and the fact that drinking water is extracted from deep layers. *(P11) "If you no longer spray your garden with drinking water, but use a groundwater well, we are actually much further away from home, because then you will use that very shallow groundwater, which has a more direct influence than the deep water."*

There is also sometimes too much focus on the drought aspect and climate change, which leads to longer periods of drought, why measures need to be taken. While many of the measures taken by governments in this area are not merely aimed at preventing droughts from happening, but at adapting the water management system so that the system is more resistant to longer periods of drought.

(P9)" I don't think we have an influence on the climate worldwide and certainly not we as the Netherlands." This does not mean that it was not recognized here that longer retention measures also have advantages, but the focus was not imposed here. The awareness of exactly what the measures are used for and how this relates to drought and desiccation is also important here. The measures that are proposed are in many ways aimed at preventing desiccation and not drought.

It is also important that private individuals are aware of drinking water consumption because this water comes from the water system and therefore indirectly affects the groundwater level. One of the tracks that the drinking water company uses is therefore *(P11): " increasing social resilience by raising awareness and conveying the realization that it is not self-evident that there is infinite water."* This is not only about drinking water, but also about how the layout of gardens influences how rainwater is retained in the gardens.

The measures taken by the municipality to raise awareness are still limited and mainly focus on campaigns about rain barrels, tile seesaws and limiting drinking water consumption. The water board is also focusing on these points when it comes to awareness messages to residents, and more and more communication is being done via social media to citizens about climate-adaptive measures, green roofs, disconnection, and installing rain barrels. At the same time, awareness among the more organized stakeholders in the area is also being worked on. By involving the business community, farmers and nature organizations in policy as much as possible.

It is also very important to announce certain changes in a timely manner so that this can be incorporated into the business operations of landowners. Setting a timeframe creates foreseeability, so that even if changes are necessary for the public interest, they can be implemented slowly in the business operations of an individual in an area to maintain support. This is legally necessary to ensure that it is permitted by law, but also provides the time to reasonably arrive at a different situation together.

The time frame of this foreseeability depends on how far-reaching a measure is. The water board has indicated that it will maintain the current protection levels until 2030, but from 2030 it will emphasize the targeted water level decisions (Waterschap de Dommel, 2023d). *(P5)"In all those building blocks you can see that it is a lot of stimulation until 2030, with money with arrangements to try to get things done together and after 2030 it is still the idea that we can enforce more things, that more is anchored in regulations and that we will simply no longer facilitate some things."*
It is then the task of the water board to indicate clearly and in a timely manner what can be expected in terms of groundwater levels during the year: (P5) "*I think that the water board should properly indicate how high the groundwater level is during the year, because in the spring the groundwater level is not the same as in the summer and not the same as in the winter. So what do we expect as average groundwater levels in the different periods at that location.". "But also what do you expect from flood frequencies of certain pieces of land, does it flood there once a year or once every 10 or 20 years. That makes quite a difference for an entrepreneur to see what to do there. The clearer you are about this as a water board, the better you can respond to it as an entrepreneur."*

Communication and looking for possibilities together is therefore seen as an important aspect by the water board in order to create more support for changes. *(P5)" Those explorations are taking place at different levels. That's not 1 conversation, it keeps coming back. Those are quite difficult and interesting conversations."*
Better knowledge and awareness could therefore contribute to the acceptance that it is becoming wetter in the stream valleys and that groundwater levels are rising. This, according to some, can also be seen as a new equilibrium, not in the physical, but in the social sense. *(P5) "If that is much more generally accepted then that is also a kind of balance."*
From a nature perspective, desiccation has been on the agenda for decades and many policy measures were taken for this 20 to 30 years ago, but this always happened somewhat at a local level and each area was examined, in particular nature reserves. The newly emerging awareness and urgency following the drought problems of recent years has led to changes in the approach. *(P12)" The benefit of this awareness is that many solutions are not 1 dimensional. You cannot solve natural problems in nature reserves, the environment also plays a role in this "*

The current situation actually illustrates a tragedy of the commons situation that is currently taking place and has taken place in the past in the way of water use. The individual use of water from the various sectors: industry, agriculture, private use, ensures that the collective slowly depletes the common good 'water'.
The influence of the large industrial extractors and drinking water extractors has consequences for the water level in the agricultural area from which they extract. As a result, a farmer is more likely to be forced to extract shallower groundwater, which in turn leads to a fall in these groundwater levels. *(P12)" So no one is the cause here individually or as a sector and there is also not 1 sector that can solve it on its own. It is therefore important that everyone plays their part and that the finger is not pointed at what other sectors are not doing well."*
Awareness of this confluence of circumstances is therefore considered necessary in order to accept changes as a result of breaking through this concurrence.
System knowledge is very important in this regard to know what the zone of influence is of an area. *(P12) " Then you need a policy that ensures that the use of the water in that area is also controlled. " so that account is taken of several stakeholders and that the withdrawals of large industry, for example, do not lead to damage in nature reserves."*

(P10)"So it first starts with knowledge, knowledge that this is how it works and then the awareness that it matters and also matters what I do and then the third part of the behavioural change, that people actually start to change their behaviour." The increasing awareness of the drought problem and its impact on several aspects of society also makes change in this respect somewhat easier in democratic governance. *(P2)" It will also be easier to take the council and the council with us if we also want to prevent the drought and solve the drinking water shortages."*

Increase legal and political decisiveness

In the interviews it was indicated that in order to be able to realize the measures that should lead to a more robust and resilient water system, certain policies or regulations sometimes still have the opposite effect, or that legal decisiveness is lacking to be able to implement the new measures.
From a policy perspective, for example, it often proves difficult to properly test new water questions and, in some cases, to reject them. *(P12)" Sometimes you see things happen that you think how is this still possible, but it still happens according to the rules."* This then seems contradictory to the vision that the rules are trying to realize, nature conservation in this case. Within the current policy, therefore, interventions in the area are still possible and practices that do not promote the conservation of nature, while the aim is still to protect these areas.
Despite policy and efforts to protect nature, current policy does not result in, for example, that wet nature doesn't dry out in the current outcome. (*P12) "The fact is still that many areas are desiccated, that polder utilization is taking place in a number of places with regard to groundwater, resulting in damage to nature."*
It is also experienced that the overall water management policy still emphasizes a surplus of water instead of a shortage. For example, situations are described where causing flooding between sites is not permitted and can count on damage compensation in certain situations, while the extraction of water from areas, which can ultimately lead to desiccation in adjacent plots, cannot count on these regulations or compensation.
(P5) "There are national standards for flooding, for how often something is allowed to flood. This does not really apply to drought." This view is also reflected in the claims for damages. *(P5) "Now it is often with flooding that the water board is looked at, are you to blame there and can I claim damage, fortunately this is not the case with drought, on the other hand it also means that there is less consideration for drought."* The water board's statutory instrument, the Keur, is also more geared towards preventing flooding than preventing drought related damage. *(P5) "For example, that the rules for digging a new waterway are in principle more flexible than rules for filling in water."*

Creating clearer regulations could thus contribute to increasing the decisiveness for achieving goals and measures to make the system more robust.
(P2) "With a national measure that weighs more heavily, you are in a much stronger position to guarantee those objectives. Otherwise, it will be the alderman who says yes, but we need that money.'

Legislation also stands in the way of change for greywater systems. This is about splitting drinking water and rainwater into what we use water for in and around the house. At the moment, a lot of high-quality drinking water is still used for things for which this is not strictly necessary. *(P10)"They call it drinking water, but how much do you drink in a day? 2 liters? While we use an average of 130 liters per person, but that goes to flushing the toilet etc "*
For non-hazardous purposes, it is therefore being considered whether drinking water can be replaced by greywater. To make this possible, requests are made to the national government to have legislation amended in such a way that it is possible to use greywater systems, i.e. purified rainwater.

Decisiveness depends on how decisions are made and which interests predominate. Taking certain measures that will have a major impact on the environment and could create commotion from stakeholders is therefore politically complicated in some situations. *(P1) "But that is very sensitive because we are a democratic organization and the board likes to say yes to things, but not such difficult decisions, they are politically sensitive of course "*
For example, advice can sometimes be given from the civil service that, for certain reasons, is not acted upon politically. *(P3) "We try to paint as clear a picture as possible for directors to make decisions on that basis. But, in practice it sometimes happens that the political reality makes a different choice than what we have officially advised."* What was also mentioned in this area is the lack of clear leadership on spatial planning and the social issues associated with it. There used to be the Ministry of Housing, Spatial Planning and the Environment, but that is no longer there. That is why national spatial planning is no longer registered and there is no longer a minster specifically for this department. While it was stated that: *(P11) '"These kinds of issues call for someone who dares to make unpopular choices for the long term."*

Designing the landscape in such a way that it makes the system more resilient also requires the search for integration between certain sectors in addition to adapting to the environmental characteristics of an area. These are issues that, because of their complexity and interdependence, require a kind of design framework.
Current environmental law is still made up of partial interests and therefore hardly promotes a coherent approach. The legal possibilities to achieve this are available, but are currently not being used. The Land Development Act was a law that was passed into the Land Development Act (WILG, 2006), which in turn was incorporated in virtually unchanged form in the new Environment and Planning Act (Advies Commissie Droogte,

2022).
The new Environment and Planning Act aims to organize and clarify the legal options, especially with regard to the environmental vision and the municipal environmental plan. This law integrates various aspects, such as spatial planning, the environment, traffic, water, construction, nature and heritage, so that opportunities and developments within municipalities are better viewed in conjunction. The aim is to approach projects in a coherent and area-oriented manner, and no longer based on conflicting partial interests. Not focusing on one partial interest, but viewing an area as a whole also fits in with the realization of a more resilient system (Ministerie van infrastructuur en milieu, 2016). This could potentially contribute to increasing decisiveness, but depends on the choices made in this respect. However, it is currently unclear what the law will entail exactly. Whether this will help lower governments to actually implement measures will therefore have to be seen when the law is actually completed and enters into force on January first 2024.

Increasing Cooperation and assistance

In various local and regional programs, the importance of cooperation and joint search for a solution is underlined several times. To this end, the water covenant can become the embodiment of cooperation in the region, but other partnerships such as work units also contribute to achieving objectives.
To increase the impact of measures, it is also mentioned that collaborations are entered into to be more effective. *(P2) "You can do small fragmented things, but you can also say we look across the border and we do something together somewhere and invest outside the municipality with a number of municipalities to prevent desiccation in an area, instead of just taking those small stamps within the municipality."*
Collaboration is also considered important in order to arrive at integrated policy as a local authority and thus to add policy decisiveness and feasibility. *(P2)"It is a small municipality and many departments are busy with their own things, so then you won't get to a really integrated policy that quickly, where a number of people are set up to really get started with it" " That is actually also the reason that we are in that work unit and that such a stress test is done by the northeast Brabant region, because we simply cannot manage that ourselves. We are too fragile and too small for that."* This cooperation with other municipalities in the area to tackle things in the region is therefore necessary for a smaller municipality because it is not big enough to really tackle those problems on an individual basis.

In realizing plans, the water board also depends on cooperation, or at least assistance, in certain cases.
For example, the water board is dependent on others for the implementation of drainage policy, surface water level management, the installation of weirs and the like. *(P5)"However, where the maintenance and ownership lies with third parties, we do depend on their cooperation."*
Which in turn makes taking measures more complex and shows the need for benevolence on the part of other parties.
The water board is also dependent on the area-oriented approach for the realization of 'function follows water level'. In these area processes, governments and local parties in a certain area work together on the challenges that arise and try to find a solution in this way.

The all-encompassing nature of the measures needed to make the system as a whole more resilient also means that different stakeholders are needed to solve these problems. Good cooperation can therefore be seen as essential.
However, the collaboration also has its caveats with regard to effectiveness. For example, it may not always end up with the physically desirable situation. *(P5) " The current reality leads to the situation that on the one hand you really have to do it together and get all parties on board for social resilience in society, but on the other hand you are constantly making concessions, which means that you do not actually get the ideal situation for the water system."*
The Advies Commissie Droogte (2022 p7.), mentioned that in order to accelerate and scale up the cooperation between parties, a reconsideration of the current cooperation model is needed: "From consensus to accelerated decision-making, in order to achieve coordinated implementation of measures." they also recommend appointing an independent and authoritative drought director to support this process.

Reducing physical and institutional barriers (path dependencies)

Taking measures in the physical as well as the social sides of the system is influenced by physical & institutional barriers. As described earlier, in water management there is a tendency of focusing on the nuisance of too much water and the maximally efficient use of the land for which it had to be developed. This creates a way of reasoning and thinking that influences how laws and regulations are formed. New decisions then often follow these dominant paths, showing the path dependence. The above-mentioned obstacles from the law and regulations, as well as the tendency towards a certain way of consciousness, fall under the so-called path dependencies.
From the perspective of ecology, the system has been intervened in such a way according to a certain mentality that there are all kinds of obstacles to get it back to a state that is more balanced. *(P12) "The system has been modified to such an extent that there are all kinds of obstacles to fully restore the system."*
The water management we currently have, which is mainly focused on flood protection and drainage of the land, is still the dominant ideology. The one-sided focus on this form of water management hinders the changes that are considered necessary to make the system more resistant to drought. As a result, developments are still taking place that conflict with the long-term vision of, among others, the water board.

This way of thinking was also mentioned as dominant within the municipality. *(P2) "That climate is robust, that was actually first assumed from flooding, so that is actually the starting point. The win-win is actually that we will also retain and infiltrate the water. The reason is to keep your feet dry."*
At the same time, the ground pressure is also quite high due to the demand for space from various sectors. *(P12) "we also all want factories and prosperity, roads and agriculture".* As a result, the interests are very high for almost every area, even parts that are actually not ideally suited to the function they occupy.

For example, choices have been made in the past to create drinking water wells in certain places or to expand cities in historically low areas, which cause problems in the current situation. The water loss that this entails for an area is difficult to remedy.
The method of spatial planning therefore means that the realization of a more resilient system is influenced by choices made in the past. *(P1) "A lot of things are in the wrong place when you reason it from the water perspective."*
For example, Eindhoven airport, but also the aforementioned highway near Best, is located far too low from a water perspective, so that when it rains the water has to be drained there. Eindhoven and Tilburg also have a very high-water table, which has consequences for the way of drainage and the risk of flooding. The physical historical developments from this water and land management ideology are seen as obstacles to the desired changes towards a more robust system against drought, but at the same time it is not considered desirable to relocate residential areas. *(P12) "There is such a situation at Eindhoven, where you can never restore that seepage flow because there is simply a residential area there. So there you actually ended up in a new equilibrium, that is just the reality there and you do what is reasonably possible there."*

Measures are then taken at these locations to restore the water system against water shortages that suit the area but still fall within the current function of land use without disrupting this function, eg housing, with flooding. *(P3) " It is thought from an ideal situation, but you just know that you are dealing with preconditions from the past that cannot be removed from one moment to the next."* The above-mentioned situation will then probably lead to a compromise system for what is most desirable given the current situation.

Main measures	Instruments
Dealing with financial aspects on the basis of solidarity	- Devaluing land (in stream valleys) that is degraded due tot the changes. - Making it financially attractive to disconnect homes from the sewerage system in terms of rainwater - Subsidy schemes to litmit the burden on beneficial change. - A strong price incentive: A staggered rate system
Increase awareness	- Communication via social media to citizens about climate-adaptive measures, green roofs, disconnection, and installing rain barrels. - Setting a timeframe for the intended changes to create foreseeability - Communicate about existing path dependencies and the importance to break these paths. - Raise System knowledge to create a better understanding in the zone of influence of an area
Increase legal and political decisiveness	- Rectifying the imbalance between regulations and subsidies between drought and flood problems - Balancing the Keur again to be geared towards preventing flooding as well as drought related damage - amend legislation in such a way that it is possible to use greywater systems, i.e. purified rainwater. - Use the new Environment and Planning Act in line with the environmental vision of regional authorities and the municipal environmental plan to stimulate integration.
Increase cooperation	- Partnerships between municipalities and other authorities. - Good cooperation or assistance (based on agreements) between stakeholders in the area (grondwaterconvenant) - A reconsideration of the current cooperation model - Appointing an independent and authoritative drought director to support the process

4.5 Perspectives on Resilience

Based on the documents and interviews analysed, certain perspectives emerge on how resilience is viewed.

4.5.1 Similarities in perspective on resilience

when it comes to acknowledging a drought problem, there is agreement among stakeholders. It is also clear that measures are needed to reduce the negative impact of this. For example, the importance of retaining more water to a certain extent is seen by all stakeholders as an important aspect to better withstand drought events. The different sectors are all negatively affected by prolonged periods of drought and therefore benefit from measures that contribute to a larger freshwater buffer to cope with these periods of shortages. The similarities in vision on resilience are particularly evident in the realization that problems arise due to longer periods of drought, for which action must be taken to become more robust in these situations. The shortages that arise in the various sectors must be compensated by taking measures to regain or retain the water. The consensus between stakeholders begins to change when it comes to the actual measures and at what level this should be addressed. For example, some stakeholders look more at the individual level when taking measures, which are mainly of a technical nature, while other sectors look more at the system in its entirety and look beyond the technical measures of robustness, to possibilities for adaptation of land use and the transformability that is required for this. Nevertheless, there is agreement between stakeholder on what needs to be accomplished in the groundwater covenant about general structural groundwater elevations with clearly indicated increases per area of 10 cm in the lower, level-controlled and in some cases already wet parts of Brabant and by at least 35 cm in the higher-lying infiltration areas. Despite the fact that the 'how' question not further explained here, there is a goal that can be strived for together.

4.5.2 Difference in perspectives on resilience

Nonetheless, as described briefly above on several points there are different points of view in how resilience should be achieved

Land-use specific oriented

A difference in perspective can be noted in the agricultural sector, which looks for resilience more at an area-specific level and takes measures of a more technical and spatial nature to make each area more resilient to a drought event. The resilience that would be achieved here therefore mainly relates to the area in question. For example, more water retention is being looked at, but within the current land use functions. *(P4)"Above all, keep talking to each other and look for a method that fits and I certainly don't think you should forget the technical side and maybe we should go a little further with a very well controllable drainage system."* The basic position here remains that it can be decided for each landowner what will make the function of the land use more resilient. *(P4) " So a farmer has to do what is best for his soil on his plot and they have to think about how can I make my soil more resilient.*" A stable point between flooding and drought could then be achieved through adequate technical intervention. *(P4) "You can then reach the equilibrium point by making the soil more resilient and having a good drainage system."*
Because this form of resilience is still very much focused on the water level adapting to the function of land use, there must always be an escape clause for becoming more resilient by means of water-saving and buffer-enlarging measures. *(P9) "You have to be able to steer it, so that if the need arises that you can still let it go." "We cannot say that we will mainly focus on retaining water in the coming years, because it will be dry. Whatever system you come up with, you have to be able to control it. Otherwise, it will go left or right once wrong."*

System oriented

There is also a perspective that looks more system-wide at what it takes to be resilient. The water board is the most progressive in this respect with its vision, described in the water program and the water transition implementation strategy. These emphasize the importance of joint implementation of the measures in order to create the desired effect at system level.

In essence, we are working towards the idea that there will be more room to move without this immediately unbalancing the system. The general goal here is to move away from a system that is quite dependent on ad hoc measures and that involves many technical interventions, and therefore requires a lot of steering. *(P1) " We want a water system where we are constantly balancing with a small margin, to a robust water system that can simply take a lot."* A very technical system that has to be constantly balanced with small and large interventions is very laborious and is therefore seen as more vulnerable. If something happens, this immediately has a much greater impact and you are therefore less resistant to a drought event, for example. Because of this, it is necessary to have the possibility to do it in different ways when confronted with different environmental characteristics. This means that, based on the environmental characteristics, the water must be given the space for a more natural course. *(P5) "If we say, we want to move towards a more resilient and robust water system, then it is first of all creating more space for the water." That it just naturally gets a little more space in the stream valley, but at the same time that it starts to meander, that the basin becomes smaller, shallower."* This way, the drainage is slowed down which results in a system that is better able to handle retain water and provide the possibility of infiltration, while at the same extent the period water travels in the system, making it better equipped to handle peak showers of rain as well.

The measures proposed in these documents mainly focus on making the system more robust. At the same time these and other measures are focused on slowly adjusting the layout of the system to one where it accepts drought events and is prepared for them. *(P5)"The appropriate measures are even more about becoming robust and looking at adaptability to the situation, mainly with technical measures. In the current situation, for example, weirs are still being placed that contribute to water retention, which helps to become more robust and move in the direction of the transition."*

The province also assumes that several actions must take place at the same time if the measures are to have the desired effect. *(P10) "It's a combination, and that's what makes the problem so tricky, you have to do a lot of things at the same time to get an effect. So with only reducing irrigation, that is a very big step to take in this, but that alone will not get us there."*
When is system can be considered resilient or how such a system would exactly look like is still unclear and uncertain. *(P10)" That's a discussion we're following, of what makes a robust system. When is a system robust and when is Brabant climate-adaptive, because we have said that Brabant will be climate-adaptive in 2050. But how do we know that?"*

A certain balance or equilibrium point can therefore not yet be clearly indicated for many. *(P5) "Maybe you also have several" "How much groundwater you extract and how much groundwater you get replenished, I think that is also such a point of balance, where we are now actually out of balance." "But I also think that a point of equilibrium is that you say, you actually want the system of what happens on the high heads, on the flanks and in the stream valleys, you also want to get a balance there again, that seepage currents run again. Now you keep doing things artificially." "Now we are using drainage and irrigation as if all places could be treated the same. While I think you also have to accept that the natural conditions are different in different places and that there are also other functions."*
The preconditions for the vision of a resilient system can already be deduced from this. In line with this, it is also indicated that the search for what a resilient system looks like exactly within these preconditions is an ongoing process. *(P3) "That you do indeed try to extrapolate a certain development into the uncertain future and that you constantly adjust it the further you get. "*
For a balance or equilibrium point, a dynamic equilibrium as it exists in ecology was therefore mentioned several times. *(P10) "The characteristic is that there is never a static equilibrium and it is never just one equilibrium in ecology, but it is an ecosystem. But actually, also in a water system there are always several scales that all influence each other"*
A static equilibrium is actually no longer considered realistic, because the linked systems within this ecosystem have already adapted to the changes that have been applied to the affected aspect of the system. As a result, you will always maintain a dynamic equilibrium.

The perception of resilience is perspective oriented

The perspective you adopt is therefore very important for what is seen as resilient.
It therefore also partly comes down to what you want as a society or where the emphasis is placed and what consequences this has for what the system looks like. *(P11)"So the question is actually what is your goal, what are you working towards. A goal is not higher groundwater levels, but this is a measure to achieve a certain goal."* An important question that was asked is therefore who do you do this for and when is the system good? Which indicators are associated with it. *(P11) "Is that if plant A continues to live in area B? That is of course very paper reality." "Ultimately, they are social choices. That society also chooses this and that the damage is not too great. So that you do give farmers a perspective." "Essentially, this is about how you arrive at a good perspective for action for everyone, because there is no truth."*

The focus of agriculture is mainly on making the land use function resilient and this is therefore central here. Over the years, the demand from this landscape however has only grown due to increasing efficiency. *(P1) "We have been getting more and more off the ground. Now 5 or 6 times more grass is harvested from the land."*
The perspectives of a more natural system and a system that seeks to achieve maximum efficiency will then be partly contradictory in areas where the conditions for this do not match. *(P4) " Yes, that works, there is nothing better than a natural system of course, but it does not fit in with our philosophy, because we want to harvest a lot from our land, we want to have production."*
Extra yields also require extra input. *(P1)"If you can irrigate, you can collect even more and that also depends on the price of land or the market where the farmer wants to sell it. So there are a number of natural tipping points, but of course there are also a number of political choices and trade-offs that you have to make." (P7) "If you only want to have heathland or only sand drifts, then it does not matter how low the groundwater level is. And if you want very wet nature that belongs to stream valleys, then yes, you need much higher groundwater levels."*

In the Netherlands we have already imposed obligations within this system in the field of nature in the form of Natura 2000 areas and other regulations. In these agreements you could say that nature is taken as a perspective for resilience. In spatial planning, however, this perspective conflicts with the perspective of resilience for agriculture in certain areas, in its current form and how water management functions in it. *(P11) "The obligations in the field of nature then almost become an artificial goal, but in the end it is of course about quality of life and* *biodiversity and how do we keep the Netherlands liveable for the people who live there and perhaps even more broadly."* In that respect, the drought issue is actually a social issue that transcends drought and desiccation.

In a sense, therefore, there is already a kind of equilibrium that is strived for from the past that takes into account areas with special nature. These measures are supposed to protect nature in terms of water management, but these measures are not perceived as sufficient and can therefore not yet be seen as a resilient system for the natural value: *(P12) "If you ask me, just by looking outside and at developments in nature areas, that is not enough at the moment."*
Determining what a resilient system looks like is also experienced as a complicated discussion from a nature perspective. By significantly changing the social domain over the past 100 years in terms of population, industry, wealth, roads and agriculture. This also affects the possibility of recovering the system and what you take as an end goal in it. A large part of these changes, however, has to do with how we use the system. *(P12) "So those are just choices we made to set up and use it the way we do it now and we say that there is still a lot of low-hanging fruit to be picked for how we can make it better."*

Not everything can be allowed from a road infrastructure perspective either *(P7)"If it is said, we want those road ditches 30 cm below the asphalt edge, we cannot allow that either because then the road will become unstable."* These kinds of physical obstacles, as also described in 4.3.3, create a situation where the resilience of one perspective does not match the other. In this case road perspective versus system perspective. *(P7) "So that is sometimes still difficult to take into account. The resilience of the total system in the decisions for the resilience of the road surface system."*

A resilient and robust system will therefore partly consist of restoring the system as far as possible that takes into account natural environmental characteristics for each area, but at the same time takes into consideration the preconditions of some land functions, such as residential areas in stream valleys. *(P12)"If you are close to the city you often have many obstacles and if it is in a very large nature reserve then you often have fewer obstacles." This varies per environment and land use situation."*

For this reason, the province has therefore chosen not to strive for a natural, but for a robust water system. *(P10) "That is why we have chosen the term a robust system and not a natural system. Because since the Middle Ages, or probably since the Romans, interventions have been made in the water system in the Netherlands" " So we are not going back to a natural system, we are going back to a robust system and part of that robust system is that we extract less."*

The Advies Commissie Droogte (2022), state in this regard, that it is no longer desirable to function 'separate from the soil' in actions. Therefore, environmental characteristics will have to be taken into account in planning in the future. This also means that this vision of resilience moves away from an exaggerated idea of manufacturability, towards a system that moves along with the natural (ground)water flows and in which nature as a water-dependent function becomes equivalent to other water uses.

5. Discussion & Conclusion

Literature shows that drought and climatological changes are the unpredictable phenomena that create uncertainty and to which a system needs to become resilient.
Drought is something where the literature and the results are quite similar in description and how it is experienced. For desiccation this is somewhat more complicated in some cases. For example, the term desiccation is also used in the results to indicate drought damage in agriculture by interviewees, while the literature speaks of desiccation as a phenomenon related to nature (Van den Eertwegh et al., 2021). This was also described in this way in other interviews, but the terms drought and desiccation were in some cases used interchangeably, which shows that the idea behind desiccation and what causes it is not yet generally known or that this is not fully realized. Therefore, in some instances the idea might arises that the drought aspect and climatical changes are the target being tackled, while many of the measures taken by governments in this area are not aimed at changing this, but at adapting the (water)management so that the system is more resistant to longer periods of drought. A clear distinction between drought and desiccation as well as awareness of the system functioning and related problems and the link of this to the occurrence of desiccation might be of importance to increase people's acceptance of certain measures.
Although this knowledge is present with many of the experts, it should not be regarded as common knowledge. The continuation of awareness raising in this regard can help create more awareness on what the proposed measures are really for and how this relates to the drought issue.

In order to become more resilient to drought in an ecological sense, many spatial and technical measures are proposed, which also require the adaptation of certain land use functions in the physical space for a successful impact. For example, you could argue that in both cases water and drought are actually spatial issues, or problems that can in any case only be solved in spatial planning. The amount of water and the problems this causes, both drought (too little) and flooding (too much) are more givens in this that we can adapt to in various ways to make

the system more resilient. These are often only spatial interventions because this is the stage where the problems ultimately really manifest themselves.
Where drought differs from flooding with regard to the assessment characteristics described in Restemeyer et al. (2015), is that this is not a direct hazard, but a creeping phenomenon. As a result, in terms of transformability, the possibility to transform in the face of hazards is more difficult due to the complexity of the problem and the gradual impact it has, which does not affect every stakeholder in the same way.

According to Davoudi et al. (2012), The resilience-building literature tends to prioritize planning for post-disaster emergencies, with a focus on addressing sudden, turbulent, and large-scale events, while overlooking the importance of addressing gradual, small, and cumulative changes. This tendence can also be observed in the drought management, with several measure of making the system more robust. On the other hand, there is a wide consensus among several stakeholders in the area, on the importance of tackling the structural negative impacts that are present in the current design of the system. This is proposed, among other things, by structurally raising the groundwater levels.

The properties as described in Restemeyer et al (2015), and used in this paper to analyse the measures for becoming more resilient to drought, generally correspond quite well to the topic of drought despite that the assessment framework was created for flood resilience. Nevertheless, in some cases it was difficult to indicate some measures to a specific property. For example, the measures that make the system less vulnerable by making adjustments to the land-use functions, in order to combat desiccation, have an indirect positive effect on making it more robust against drought. This is because changes in land use allow these areas to retain more water and thus increase the groundwater supply. Allowing higher groundwater levels through this adjustment of functions means that more water can be retained in an area, making the system more robust against drought due to a larger buffer capacity. The measures that fall under the discouragement of vulnerable land-use and adjustment of functions can be placed under the requirements given by Restemeyer et al. (2015), for adaptability, but can also be seen as a robustness measure due to their water retention capacities.

Adaptation measures for drought are viewed from the entire area/system because adaptations from the higher areas towards the stream valleys influence each other's resistance to drought. This does not necessarily affect the classification of the measures as it is now made, but indicates the overlapping context in which this distinction is made. On the other hand, the overlap between the impact of robustness and adaptability measures clearly shows that it is important that the measures are implemented in conjunction, as is evident from both the literature and the results.

A general goal among several stakeholders in the area translates in a general sense to more control on groundwater, by means of groundwater-driven management in order to work towards a climate-proof and resilient water and soil system that can withstand extremes. This is mainly focused on preventing desiccation in order to make the system less vulnerable to drought events. In addition to the structural fall of groundwater and the resulting shortages, it is also seen in the literature as desiccation if water is brought back from another part of the system for nature purposes. In practice, this requirement is also met as the water from the Meuse is supplied through a system other than the restored streams. The intention of this disconnection, mentioned in the results, was mainly related to the slower discharge of rainwater to enable infiltration, but this main purpose has the side effect that the definition of desiccation mentioned by Van den Eertwegh et al. 2021), which mentioned that an area can also be desiccated if water of a different, foreign quality has to be supplied to compensate for a groundwater level is also met.

As mentioned earlier, the measures of robustness should provide redundancy and a buffer capacity, but despite the fact that a number of these measures are already being deployed at the moment, this is not done in a coherent way. For example, there are meandering projects that are currently taking place as well as investigation into how the infiltration capacity could be increased by reducing petrification and increasing efficient irrigation methods that reduce evaporation, but this is not yet happening on a large scale. Creating redundancy often isn't limited to one thing, in fact, the more diversity there is present in a system, the more resilient it is perceived. The use of various ways of acquiring and conserving water is therefore something that various policy documents focus on. A negative side effect of the redundancy on the other hand, could be that the abundance in one area, might have consequences for another (Wilkinson, 2012). This is also the case in the case study area, as some land-use functions will be adversely affected by a rise in water levels. Despite that, in order to achieve resilience in a system, it is considered necessary to raise the water level in all parts of the system in order to give the measures that fall within the robustness framework, the capacity to retain the accumulated redundancy. At the moment, the case study still lacks the realization of the larger adjustments in the area so that this is more in line with the environmental characteristics. Efforts are already being made to this end, but realizing this is proving quite difficult. Due to the negative impact redundancy can have on certain land-use functions in their current form, measures that work against drought quickly become a risk for these kinds of land-use functions, which leads to increases of resistance towards certain measures and make it difficult to come to a consensus or agreement on a widely accepted approach.

In practice, therefore, stakeholders often resort to the technical measures that are classified within robustness. this is in itself an explicable reaction because these are often measures that a stakeholder can achieve within their own capabilities. For example, the water manager can adjust the water system, but not the land use functions.

Therefore, similar to the findings of Restemeyer et al, (2015), drought management, in order to be successful, cannot be seen as a purely public task. The presence of complexity, uncertainty and the consequences it has on a diversity of stakeholders create a situation where it is not feasible for a government alone to tackle these issues. The interconnectedness of the system makes individual measures in areas helpful, but not adequate to tackle the issue in its entirety. For example, raising a weir will not have the desired effect if the underlying reason, due to which the water level was lower in the first place, would not be taken into account in the measures.

Because it concerns one system, the socio-ecological system, with a multitude of stakeholders involved, there is a great necessity to approach measures in an integrated manner. As mentioned in section 2.5, Rijke et al. (2014), state that in order to become resilient in water management, it is necessary to integrate with other sectors. This was also mentioned in the results. For example, in the form of using water that is pumped away from areas where the road is located in a sunken position. There are still opportunities here that are not being acted upon at the moment. In that respect, it will be a challenge for Rijkswaterstaat to see how the highway, but also waterways under their management, can be used in such a way that it contributes more to the area in order to become more resilient to drought. This will require a highway that is designed differently and is ecologically and socially connected to its environment so that it is in balance in both cases. The need for such integration did not only became apparent for this sector, but also for urban development improving integration was proposed. The search for integration and useful ways of using water will therefore have to be analysed for every sector.

Creating a resilient system is a complex and challenging undertaking that goes beyond a mere checklist of measures. It necessitates a profound shift in mindset, that develops a culture of openness to collaboration across diverse disciplines. Equally important is ensuring that citizens grasp their roles within the system. These aspects of achieving resilience are necessary to create the adaptations in the landscape in order to create a consistency between function and area, but are at the same time the most difficult to achieve. In the case study situation, there are already advanced transition strategies, management programs and agreements that focus on an overall change that also includes the adaptability measures and recognizes that this requires transformation and therefore a transformability.

To increase the willingness among stakeholders to adjust their vulnerable land use, several things are mentioned in the literature, such as increasing awareness, but also recovery funds. In line with these funds, another option was mentioned in the results, namely that of lowering land prices in parts where there is a desire for extensive land use instead of intensive. These measures enable an owner to use land that requires less financial input, and thus allows for less demanding use that contributes to becoming more resilient.
The measures such as insurances and recovery funds fall within Restemeyer et al., (2015), their assessment criteria under the adaptability characteristic, but in the case of drought is more suited for the transformability characteristic. Drought as mentioned earlier is a creeping phenomenon and therefore does not have such a direct impact as a flood that needs to be recovered from. At the same time, in order to become more resistant to drought as a system, it is considered necessary to adapt the land use to the circumstances and, in the case of drought-sensitive areas, to adjust the function accordingly. In such a case, a recovery fund for drought will therefore have a counterproductive impact on the intended goal.

In addition to changes in function, it was also noted that in some areas functions continue to exist that are not suitable for the natural environmental characteristics and groundwater levels. These path dependencies will then have to be adapted to this situation as far as possible and perhaps compensate with measures for the negative impact they have in an area.

To compensate for these impacts these path dependencies have the visions of (water and soil-driven) (Ministerie van I & w, 2022), as well as function follows level from more local and regional policy documents and visions, help to achieve the goal of retaining more water in the area by operating more in line with the environment and thus to be less vulnerable to uncertainties. When certain changes are then still undesirable use of integration opportunities between sectors, such as for example, draining areas such as an airport, low-lying roads, or the Wilhelmina Canal can, through integration with other sectors, supply their abundant water to other sectors can help in achieving the desired goal as closely as possible.
How you then implement those measures is also part of your resilience. For example, you can make something technically resilient, but if you do not make it broad-based enough in a society, then the social basis may not be resilient, risking the change that the technical part will not hold up in the long term or even denying the opportunity of a change getting off the ground. It therefore seems important that changes in the system are brought about in such a way that social resilience is also created. Yet, it is also mentioned that a reconsideration of the current cooperation model is needed, from consensus to accelerated decision-making. Given the annually recurring risk of drought events, a balance will therefore have to be found between the progress of measures and the level of support that comes with this choice.

According to Restemeyer et al. (2015), in order to achieve true transformability, it is necessary to have power, resources and public support. The main factor that determines the success of transformability, however, is the ability to cultivate a shift in societal norms and values, as altering people's behaviour and mindsets is a fundamental prerequisite for bringing about tangible change within a system.

That is why governments are focusing on awareness. This is done through conversations between stakeholders, but also through awareness campaigns. In this case, it is mainly about the awareness of the entire system and how

the current way of acting leads to desiccation. In addition, there are also situations where a more specific look is taken per stakeholder and what possibilities there are to reverse a negative impact. However, this is not yet fully understood or does not result in the desired results. Good and timely communication is also considered important in the transition to a more resilient system so that stakeholders have time to adapt to the new reality.
However, building social capacity asks for more than just the provision of information. To generate transformability, it is necessary to have mutual trust between public as well as private stakeholders, and cooperation in realizing the more complex challenges. This is also acknowledged in the interviews and is also apparent from the joint entering into the groundwater covenant of both stakeholder groups. Despite the fact that these goals are still formulated in an open way, they provide a clear target.

According to Restemeyer et al. (2015 p.50), “transformability in turn, requires creativity to generate new and innovative solutions, openness towards new ideas to actually test them, as well as the capacity to learn from these experiments”. In line with this argument, local and regional governments have committed themselves in their policy documents to setting up test locations to test the possibilities for an adaptation to higher groundwater levels. Indicators pointing to increasing social resilience, however, are extremely difficult to define. It is therefore not really possible to give a value to this. A possible method could be to use the The multi-stage concept to determine in which of the four stages a transition is located on the so-called s-curve (Rotmans et al., 2000). However this too remains vague and uncertain

The division of the characteristics As Walker et al., (2010), described it with “robustness and adaptability” referring to decreasing vulnerability through increasing the resilience of the system and “transformability” referring more to the increasing of adaptive capacity (or adaptability) can also be applied to the approach of achieving resilience to drought. This shows that the resilience characteristics are intersectoral applicable and relevant.

Potential definition for resilience in the case study

The measures described in the results section (chapter 4) could lead you back to a certain definition of resilience. There is not really a clear definition of resilience coupled to guide policy from the literature. Therefore, based on the measures already implemented and proposed, reference is made to a definition that corresponds to this.

Despite new ambitions, many measures and management strategies in the current situation are still geared to a more engineering resilience definition. Due to a high demand of the land, by multiple functions that strive for a specific frame in which they have limited nuisance of water, the current situation has a strong focus on the return to 'normal' after a shock event. When a drought event happens, several functions are not able to withstand this or are adapted to the possibility of this happening, but rely on technical ad-hoc measures to reduce the impact. Likewise, a surplus of water cannot be buffered in the area for a while, but needs to be discharged quickly and thus a system is perceived as resilient if it is able to return quickly to a predetermined equilibrium after a shock. Additionally, a system its resilience for this definition is determined on how much disturbance a system is able to handle before changing form (Davoudi et al., 2012). This is harder to determine for a drought event, because it is seen as a creeping phenomenon. With floodings there is a clear breakpoint in which a system turned out to be not resistant, but due to the ability of technical interventions some functions are impacted less than others in case of a drought. When looking at nature as a sector it can be concluded that the current system is not resilient in this regard as it is already changing its form, through the extinction of certain species and connected ecosystems. But other functions such as industry or shipping are affected in their forms during a drought event as well, which forces them to, for example, change their capacity. This view on resilience correspondents with the Newtonian world view which is based on predictions by mathematical rules that see the world as a mechanical system that, therefore, can be monitored by command-and-control systems (Davoudi et al., 2012). Despite the fact that it is increasingly recognized that not everything can be calculated, this management style remains predominant in the system.

With the uncertainty and complexity that comes with interconnected systems and connected climatological events, an engineering resilience perspective, that is aimed at a conserving a fixed equilibrium encounters some contradictions between the desire to return to ‘normal’, or the frame in which the functions can operate at maximum capacity, and the absence of certainty and control in interconnected complex systems.

A static equilibrium is actually no longer possible due to this absence of certainty and control in interconnected systems. Because linked systems change, the parts that are kept static in the current situation are also constantly influenced and try to adapt to the newly created situation. The pursuit of a more static equilibrium therefore costs a lot of money and the input of technical measures and is more sensitive to events. It is therefore important to ask whether the technical investments, money and size are worth the effort to keep the system at this static equilibrium, given the negative consequences this entails in addition to the laborious nature of the system that this creates. Also, if you determine a certain point in which the system is perceived as resilient, it is no longer flexible to adapt to changing situations. Therefore, in the literature, but also in the results, the presence of multiple equilibria that would be possible or the lack of a fixed equilibrium point was mentioned, resulting in a dynamic equilibrium. A situation where in the winter season the levels are allowed to rise and where in the summer it is also accepted, in land use choice, that the levels will naturally go down. This way of looking at equilibria is more in line with ecological or even the evolutionary definition of resilience. Because, rather than designing a system in a way that steers towards a system to return to its original state with technical measures after an external shock, the ecological view of resilience is not only able to bounce back but also capable of adapting in case of disturbances or changes. A system could be designed in a way that allows it to respond to crises by adapting to a new state that is better suited to the current environment and more sustainable over the long term (Shaw, 2012).

This is proposed in the policy documents by adapting landscape functions to the natural environmental characteristics. An important part of this is creating space for the water to be present in the area for longer and thus increase the infiltration capacity. Adjustments are also required, such as rewetting stream valleys and adapting the functions to them. These actions ensure that more attention is paid to the environmental characteristics and more natural water levels are allowed, which offers room for unpredictability and uncertainties. This is more in line with the ecological resilience, which depends on the flexibility and adaptability capacity of the system as a whole, rather than simply strengthening the structures as in the engineering resilience (Carpenter et al., 2001).

According to Davoudi et al. (2012), evolutionary resilience isn't viewed as a restoration of the status quo or a 'normal' of which a clear definition is lacking in most cases, but rather as the capacity of complex socio-ecological systems to change, adjust, and, as mentioned above, undergo transformation when a system is under pressure or the current situation is unsustainable. This ambition is present in the policy documents, but because a lot is demanded of every square meter in the Netherlands and there is an urge to use the land as efficiently as possible, an evolutionary form of resilience will be difficult to achieve in the system. Due to the presence of certain functions in the landscape, an equilibrium will strive for a system that can constantly adapt to the circumstances, but will never realize this in its entirety and must operate within the bandwidth of the existing frameworks. For example, we will not stop extracting drinking water, or move cities/residential areas. In that sense, the possibilities of resilience are also tied to some path dependencies that are present. However, in order to achieve resilience in this direction, it is necessary that institutional thinking about water management and area design changes to a function follows level idea and that the path dependencies that are present here, in the form of a one-sided focus on flooding, are broken.

The conclusions of this research can be summarized as follows:

What is seen as resilient depends on the perspective from which you look at it. At the moment it is mainly nature that suffers from the imbalance and bringing this sector back into balance will therefore require the most adjustments. For other sectors you could create a static balance with a lot of artificial intervention, but this is not an option for the nature perspective. On the one hand, you have political choices that determine how we use the landscape and design the system accordingly. On the other hand, these choices do lead to consequences for the ecology. Where the balance between a total dynamic equilibrium and one that is statically created by interventions is determined, and which consequences are considered acceptable in this, is therefore a societal debate. However, it is important to consider the disadvantages of the consequences of each scenario. The type of resilience used in policy is important here because it influences how the realization process is deployed. It is therefore important to use the correct definition for the intended purpose. The change process should therefore look at how frameworks for measures that contribute to a more resilient system in an ecological sense can be created in such a way that there remains flexibility in what the exact outcome will be. With complex and uncertain situations, there is no one solution or truth to strive for. At the same time, enabling joint learning and taking responsibility will provide more support and thus greater social resilience. So that a system is resilient in an ecological way, and at the same time is socially desirable.

6. Reflection on the research

The main struggle has been accurately placing the term resilience in the context of drought as part of a socio-ecological system (the case study area) in such a way that it honours the complexity of the situation, but at the same time does not make it too confusing. As a property of a socio-ecological system, resilience is related to an enormous number of aspects, so drawing a line in what should and should not be included was quite task.
Being given the opportunity to do an internship at Rijkswaterstaat brought the research, in addition to the connections that I was able to make, more depth to my understanding of the environment and the concepts that where present in the literature. The position as a student and intern as background of the researcher might have influenced the research, and therefore , influenced how questions were formulated, data was filtered, and conclusions were drawn. The preconceptions gained in these positions could have influenced the interpretation of the qualitative data in some ways.
Conducting research in the field and gaining practical experience broadened my perspective quite much and provided me with the experiences behind the theory of resilience that helped me experience the sheer complexity and uncertainty of many situations in the field.

Due to the limited number of interviewees per sector the interviewees "framing of their experiences" can bias the findings and are therefore not necessarily representative for the sector (Cope & Kurtz, 2016, p. 662). While using a semi-structured interview approach offers a lot of flexibility and allows the researcher to dive into new perspectives and insights, it does affect how valid the data is when it comes to making comparisons between interviews. on a personal note, the interviews held for this research did provide me with a lot of new insights about the practical sense of resilience and showed me the diversity of perspectives possible to view an ambiguous concept like resilience. Conducting semi-structured interviews also taught me a lot about different ways of approaching interactions in this form of data gathering and how clear communication is of great importance. Starting this research I had limited experience in doing semi-structured interviews, but the many interviews I had the opportunity to conduct taught me a lot in this regard, for which I am very grateful to those interviewed.

Further research direction

In this study, the researcher aimed to asses resilience through a practical framework by which (spatial) resilience in the context of drought can be made tangible. While at the same time discern practical measures that might contribute to (spatial) resilience in the context of drought.

Further research may focus on the added value of bottom-up governance in achieving resilience. Given that there is not an exact resilience situation that can be striven for, but rather a bandwidth in which this can be sought, cooperation and shared learning is considered an important instrument in achieving resilience. Future research could therefore look at how certain measures that increase transformability can be deployed. This is in line with the advice of the Drought Advisory Committee to reconsider the current cooperation model. Finding the right balance between a joint communicative approach and a technical approach that is mainly focused on top-down decision making is an important condition for finding an aspired equilibrium.
Another potential research direction might be focused on how policy entrepreneurs or other sources of change can contribute to breaking through the dominant ideology in water management, towards more inclusion from the drought perspective.

7. Bibliography

Adger, N. (2010) An interview with Neil Adger: resilience, adaptablity, localisation and transition., Available at http://transitionculture.org/2010/03/26/an-interview-with-neil-adger-resilience-adaptability-localisation-andtransition/
(accessed 27 February 2012)

Advies commissie droogte (2022). Zonder water, geen later. Naar een omslag in het (grond)waterbeheer in Noord-Brabant.

Allan, R.P., Hawkins, E., Bellouin, N. and Collins, B., 2021. IPCC, 2021: summary for Policymakers.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Berger, R. (2015). Now I see it, now I don't: researcher's position and reflexivity in qualitative research. *Qualitative Research*, 15(2), 219 – 234.

Berkes, F., Colding, J. and Folke, C. eds., (2008). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge university press.

Bristow, G. (2010). Resilient regions: re-'place'ing regional competitiveness. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 153-167.

Brockhoff, R.C., Biesbroek, R. and Van der Bolt, B., (2022). Drought governance in transition: a case study of the Meuse River Basin in the Netherlands. *Water Resources Management*, *36*(8), pp.2623-2638.

Carpenter, S.R., Walker, B.H., Anderies, J.M., Abel, N., (2001). From metaphor to measurement: resilience of what to what? Ecosystems 4, 765–781.

Carpenter, S.R., Westley, F. & Turner, G. (2005) Surrogates for resilience of social–ecological systems, Ecosystems, 8(8), pp. 941–944.

Clifford, N. J., Cope, M., Gillespie, T., French, S., & Valentine, G. (2016). Getting started in geographical research: how this book can help In N. J. Clifford, M. Cope, T. Gillespie, & S. French (Eds.), *Key methods in geography* (3rd ed., pp. 3-18). SAGE.

Clifford, N., French, S., Valentine, G. (2010). *Key methods in geography*. 2nd edition. London: SAGE.

Cope, M., & Kurtz, H. (2016). 36 Organizing, Coding, and Analyzing Qualitative Data. *y IP address 192.168. 10.17 on 2023/01/21*, 647.

Davoudi, S., Shaw, K., Haider, L.J., Quinlan, A.E., Peterson, G.D., Wilkinson, C., Fünfgeld, H., McEvoy, D., Porter, L. and Davoudi, S., (2012). Resilience: a bridging concept or a dead end?"Reframing" resilience: challenges for planning theory and practice interacting traps: resilience assessment of a pasture management system in Northern Afghanistan urban resilience: what does it mean in planning practice? Resilience as a useful concept for climate change adaptation? The politics of resilience for planning: a cautionary note: edited by Simin Davoudi and Libby Porter. *Planning theory & practice*, *13*(2), pp.299-333.

Davoudi, S., Brooks, E. and Mehmood, A., (2013). Evolutionary resilience and strategies for climate adaptation. *Planning Practice & Research*, *28*(3), pp.307-322.

Davoudi, S., (2018). Just resilience.

Duit, A., Galaza, V., Eckerberga, K. & Ebbessona, J. (2010) Governance, complexity, and resilience, Global
Environmental Change, 20(3), pp. 363–368.

Enqvist, J. P., & Ziervogel, G. (2019). Water governance and justice in Cape Town: An overview. *Wiley Interdisciplinary Reviews: Water*, *6*(4), e1354.

European Parliament, (2007). EU Floods Directive of the European Parliament and of the Council on the Assessment and Management of Flood Risks, 2007/60/EC, EU.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12(2), 219 - 242.

Folke, C., Carpenter, S.,Walker, B., Scheffer,M., Chapin, T. & Rockstrom, J. (2010) Resilience thinking: Integrating resilience, adaptability and transformability, Ecology and Society, 15(4), pp. 20–28.

Frey, B. B. (2018). Snowball sampling. *The SAGE encyclopedia of educational research, measurement, and evaluation. Thousand Oaks: SAGE Publications Inc*, 1-3.

Fünfgeld, H., & McEvoy, D. (2012). Resilience as a useful concept for climate change adaptation?. *Planning theory and practice*, *13*(2), 324-328.

Gallopín, G.C., (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global environmental change*, *16*(3), pp.293-303.

Glaser, M., Krause, G., Ratter, B. M., & Welp, M. (Eds.). (2012). *Human-nature interactions in the Anthropocene: potentials of social-ecological systems analysis*. Routledge.

Grondwaterconvenant (2021). Samen werken aan herstel en bewaking van de grondwaterbalans in Brabant. Grondwaterconvenant 2021-2027.

Harvey, D. (1969). *Explanation in Geography*. London: Edward Arnold.

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods*. Sage.

Holling, C.S. (1973) Resilience and stability of ecological systems, Annual Review of Ecological Systems 4, pp. 1–23.

Holling, C.S. (1986) The resilience of terrestrial ecosystems: Local surprise and global change, in: W.C. Clark & R.E. Munn (Eds) Sustainable Development of the Biosphere, pp. 292–317 (London, Cambridge University Press).

Holling, C.S. (1996). Engineering resileince versus ecological resilience, in: P.C. Schulze (Ed.) Engineering Within Ecological Constraints, pp. 31–44 (Washington, DC, National Academy Press).

Holling, C.S. & Gunderson, L.H. (2002) Resilience and adaptive cycles, in: L.H. Gunderson & C.S. Holling (Eds) Panarchy: Understanding Transformations in Human and Natural Systems, pp. 25–62 (Washington, DC, Island Press).

Kaartbank (2023). Noord-Brabant maps arcgis. Retrieved on May 18th from : https://noord-brabant.maps.arcgis.com/apps/webappviewer/index.html?id=b6414403ef5e4e9aa8875a7c366209c6

KNMI (2022). Kennis over droogte. Retrieved on February 16, 2023 from: https://www.knmi.nl/kennis-en-datacentrum/uitleg/droogte

Laeni, N., Ovink, H., Busscher, T., Handayani, W., & Brink, van den, M. (2021). A transformative process for urban climate resilience: The case of Water as Leverage Resilient Cities Asia in Semarang, Indonesia. In R. De Graaf-van Dinther (Ed.), *Climate resilient urban areas: Governance, design and development in coastal delta cities* (pp. 155-173). (Palgrave Studies in Climate Resilient Societies). Palgrave MacMillan. https://doi.org/10.1007/978-3-030-57537-3_8

Mansholtcampus (2023). De visie van Mansholt is niet alleen geschiedenis maar ook toekomst! Retrieved on May 22 from: https://www.mansholtcampus.nl/campus/mansholt/

McCombes, S. (2019). *Case Study - Definition, Examples & Methods*. Retrieved on May 14, 2023 from https://www.scribbr.com/methodology/case-study/

Ministerie van infrastructuur en milieu (2016). Omgevingswet in het kort. Ruimte voor ontwikkeling, waarborgen voor kwaliteit.

Ministerie van Infrastructuur en Waterstaat (2019). Nederland beter weerbaar tegen droogte. Eindrapportage Beleidstafel Droogte.

Ministerie van Infrastructuur en Waterstaat (2022). kamer brief water-en-bodem-sturend.

Ministerie van verkeer & waterstaat, (1994). Evaluatienota Water; regeringsbeslissing; aanvullende beleidsmaatregelen en financiering 1994-1998. Ministerie van Verkeer en Waterstaat, SDU, Den Haag, 164 p.

Moradian, S., Torabi Haghighi, A., Asadi, M., & Mirbagheri, S. A. (2023). Future changes in precipitation over northern europe based on a multi-model ensemble from CMIP6: Focus on Tana River Basin. *Water Resources Management*, *37*(6-7), 2447-2463.

Nationaal Delta programma zoetwater (2021). deltaplan zoetwater 2022 – 2027

Naumann G, Cammalleri C, Mentaschi L et al (2021) Increased economic drought impacts in Europe with anthropogenic warming. Nat Clim Chang 11:485–491

Otto, F.E., Wolski, P., Lehner, F., Tebaldi, C., Van Oldenborgh, G.J., Hogesteeger, S., Singh, R., Holden, P., Fučkar, N.S., Odoulami, R.C. and New, M., 2018. Anthropogenic influence on the drivers of the Western Cape drought 2015–2017. *Environmental Research Letters*, *13*(12), p.124010.

Özerol G (2019) National and Local Actors of Drought Governance in Europe. In: la Jeunesse I, Larrue C (eds) Facing Hydrometeorological Extreme Events. John Wiley & Sons Ltd, London, pp 171–188

Pendall, R., Foster, K.A. & Cowell, M. (2010) Resilience and regions: Building understanding of the metaphor,
Cambridge Journal of Regions, Economy and Society, 3(1), pp. 71–84.

Philip SY, Kew SF, van der Wiel K et al (2020) Regional differentiation in climate change induced drought trends in the Netherlands. Environ Res Lett 15:094081

Porter, L., & Davoudi, S. (2012). The politics of resilience for planning: A cautionary note. *Planning theory and practice*, *13*(2), 329-333.

Prodemos (2023). Bestuur en verkiezingen in het waterschap. Retrieved on May 24th, 2023 from: https://prodemos.nl/kennis/informatie-over-politiek/het-waterschap/bestuur/

Provincie Noord-Brabant (2022). Regionaal water- en bodem programma Provincie Noord-Brabant 2022-2027.

Restemeyer, B., Woltjer, J. & van den Brink, M. (2015). A strategy- based framework for assessing the flood resilience of cities – a Hamburg case study. *Planning Theory and Practice*, 16(1), 45-62.

Restemeyer, B., van den Brink, M., & Woltjer, J. (2018). Resilience unpacked – framing of 'uncertainty' and 'ada tability' in long-term flood risk management strategies for London and Rotterdam. *European Planning Studies*, *26*(8), 1559-1579. https://doi.org/10.1080/09654313.2018.1490393

Rijke, J., Smith, J. V., Gersonius, B., van Herk, S., Pathirana, A., Ashley, R., ... & Zevenbergen, C. (2014). Operationalising resilience to drought: Multi-layered safety for flooding applied to droughts. *Journal of Hydrology*, *519*, 2652-2659.

Rijksoverheid (2022). Kamerbrief over stand van zaken droogteproblematiek. Retrieved on April 20th, 2023 from: https://www.rijksoverheid.nl/documenten/kamerstukken/2022/08/03/stand-van-zaken-droogteproblematiek

Rijksoverheid (2023). Bestuur van een waterschap. Retrieved on May 24th, 2023 from: https://www.rijksoverheid.nl/onderwerpen/waterschappen/bestuur-van-een-waterschap

Rijkswaterstaat (2022). Hinder voor scheepvaart door lage waterstanden. Retrieved on march 28, 2023 from: https://www.rijkswaterstaat.nl/nieuws/archief/2022/07/hinder-voor-scheepvaart-door-lage-waterstanden

Robinson, O. C. (2014). Sampling in interview-based qualitative research: A theoretical and practical guide. *Qualitative research in psychology*, *11*(1), 25-41.

Rotmans, J., Van Asselt, M., Molendijk, K., Kemp, R., Geels, F. and Verbong, G., 2000. Transitions and transition management. The case of an emission-low energy supply.

Shaw, K. (2012). Reframing" resilience: Challenges for planning theory and practice. *Planning theory and practice*, *13*(2), 308-312.

Sluijter R, Plieger M, van Oldenborgh GJ et al. (2018). De droogte van 2018: een analyse op basis van het potentiële neerslagtekort. Royal Netherlands Meteorological Institute (KNMI), De Bilt

Smit, B., Wandel, J., (2006). Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16 (3), 282–292.

Van den Eertwegh, G., de Louw, P., Witte, J. P., van Huijgevoort, M., Bartholomeus, R., van Deijl, D., ... & de Wit, J. (2021). *Droogte in zandgebieden van Zuid-, Midden-en Oost-Nederland: het verhaal-analyse van droogte 2018 en 2019 en bevindingen: eindrapport*. KnowH2O

Van der Brugge, R., Rotmans, J. & Loorbach, D. (2005). The transition in Dutch water management. *Regional Environmental Change*, 5(4), 164- 176.

Van der Brugge, R. & Van Raak, R., (2007). Facing the adaptive management challenge: insights from transition management. *Ecology and Society*, *12*(2).

Van der Brugge, R., de Winter, R., Mens, M. and Haasnoot, M., (2020). Transities nader toegelicht.

Vis, M., Klijn, F., De Bruijn, K.M. and Van Buuren, M., 2003. Resilience strategies for flood risk management in the Netherlands. *International journal of river basin management*, *1*(1), pp.33-40.

Volkskrant (2022). Brabants waterschap komt met 'uitzonderlijke maatregel' om droogte te bestrijden. Retrieved on march 28, 2023 from: https://www.volkskrant.nl/nieuws-achtergrond/brabants-waterschap-komt-met-uitzonderlijke-maatregel-om-droogte-te-bestrijden~b80e7fdb/

Walker, B. Gunderson, L. Quinlan, A. Kinzig, A. Cundill, G. Beier, C. Crona, B. Bodin, Ö. (2010). Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners. Version 2..

Walker, B., Holling, C., Carpenter, S. & Kinzig, A., (2004). Resilience, Adaptability and Transformability in Social-Ecological Systems. *Ecology and Society,* 9(2), p. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5/ .

Water in Brabant 2030 (2017). Wateragenda voor de Brabantse omgevingsvisie.

Waterschap de Dommel (2019). Actieplan Leven-de-Dommel (2019-2022). Naar een klimaatbestendig waterbeheer in stad en buitengebied. Waterschap de Dommel, Boxtel

Waterschap de Dommel (2022). Water als basis voor een toekomstbestendige leefomgeving. Waterbeheerprogramma 2022-2027. Waterschap de Dommel, Boxtel

Waterschap de Dommel (2023a). Werkgebied. Retrieved on May 8, 2023 from: https://www.dommel.nl/werkgebied

Waterschap de Dommel (2023b). Onttrekkingsverbod. Retrieved on May 8, 2023 from: https://www.dommel.nl/onttrekkingsverbod

Waterschap de Dommel (2023c). Elke druppel telt voor 10. Uitvoeringsstrategie Watertransitie Onderdeel voldoende water. Waterschap de Dommel, Boxtel

Waterschap de Dommel (2023d). Bijlage 1. 10 Bouwstenen. Waterschap de Dommel, Boxtel

Wiering, M. and Immink, I., (2006). When water management meets spatial planning: a policy-arrangements perspective. *Environment and planning C: Government aWand policy*, *24*(3), pp.423-438.

Wilhite, D. A. (2009). Drought monitoring as a component of drought preparedness planning. *Coping with Drought Risk in Agriculture and Water Supply Systems: Drought Management and Policy Development in the Mediterranean*, 3-19.

Wilhite, D. A., & Buchanan-Smith, M. (2005). Drought as hazard: understanding the natural and social context. *Drought and water crises: Science, technology, and management issues*, *3*, 29.

Wilhite, D. A., & Glantz, M. H. (1985). Understanding: the drought phenomenon: the role of definitions. *Water international*, *10*(3), 111-120.

Wilkinson, C. (2012). Urban resilience–what does it mean in planning practice?. *Planning Theory & Practice*, *13*(2), 319-324.

Witte, J. P. M., de Louw, P. G., van Ek, R., Bartholomeus, R. P., van den Eertwegh, G. A. P. H., Gilissen, H. K., ... & van der Kooij, W. (2020). Aanpak droogte vraagt transitie waterbeheer. *Water governance*, (3), 120-131.

Yin, R. K. (2018). *Case study research and applications*. Sage.

8. Appendix

Appendix A - Interview guideline: main interview questions

- Wat betekenen droogte en verdroging voor u / jullie? (Droogte is niet per se een uniform probleem).
- Wat voor problemen ontstaan er bij of voor u / jullie in tijden van droogte met verdroging ? en wanneer begint dit op te spelen? (wat zijn de verwachtingen op dit gebied voor u/ jullie)
- Wat betekent weerbaar/veerkrachtig zijn met betrekking tot droogte voor u/jullie?
- Kijkend naar de droogte problematiek, wat zou in uw/jullie optiek een logische afbakening van (het) gebied voor het water (systeem) zijn voor het kijken naar een oplossing?

- Hoe ziet een weerbaar watersysteem er volgens u/ jullie uit, kijkend naar de droogte problematiek?

- Op welke hoofdmaatregelen en indicatoren focust u zich / focussen jullie je om weerbaarheid in de waterbalans te bereiken ?

- Wat als dingen toch onzeker of anders uitvallen? Wat zijn dan de marges in maatregelen die zijn genomen om droogte tegen te gaan?

- In de weerbaarheidsliteratuur wordt vaak gesproken over terugkeren naar of naar voren springen naar een evenwichtspunt (equilibrium) na een crisis event. Wat zou dit evenwichtspunt of dit stabiele punt in het droogte verhaal volgens u / jullie kunnen zijn?

- Bewustwording wordt ook vaak genoemd als een belangrijk aspect, maar bewustwording van wat precies naar uw / jullie idee en bij wie en hoe?
- Hoe ziet u / zien jullie de ontwikkelingen in het gebied, kijkend naar droogte op de korte – middel en lange termijn ?

Appendix B - Code tree