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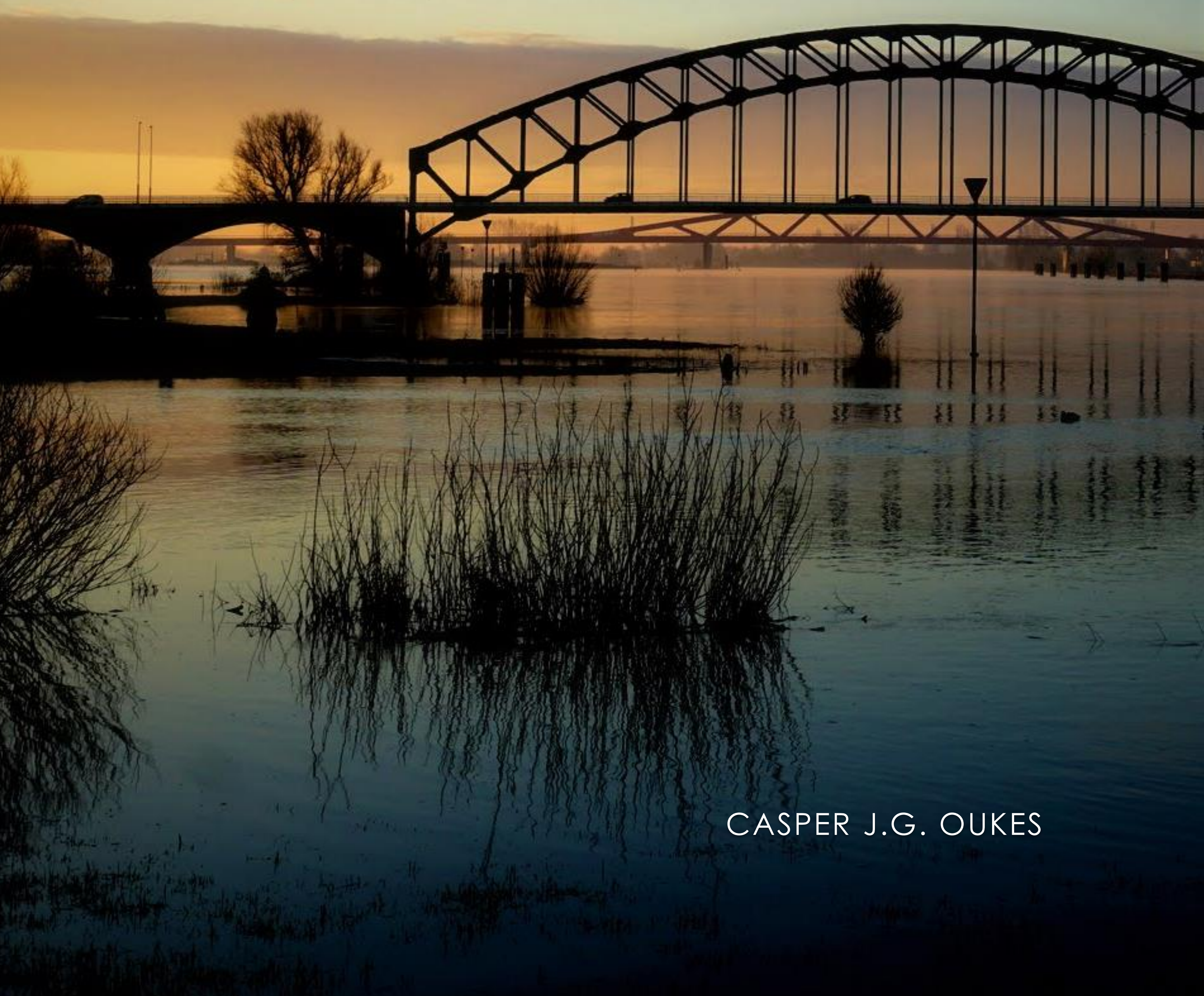
Pathways to resilient spatial planning in flood risk management

The barriers and opportunities for flood resilient spatial planning

A cloud-to-coast analysis of the city of Dordrecht and the IJssel-Vecht Delta



CASPER J.G. OUKES

“When we try to pick out anything by itself,

we find it hitched to everything else in the universe.”

John Muir, (1911)

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Colophon

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Abstract

In the current Anthropocene, all around the world, deltaic and coastal regions like the Netherlands are facing major challenges. On the one hand we face global climate change, sea-level rise, and increasing extreme natural events. On the other hand, land is sinking due to land subsidence, and it is exactly these coastal regions that host large amounts of people and economic value. This combination makes us very vulnerable to floods and flooding. With adequate water management we try to balance this volatile scale. The Dutch government tries to achieve this by operationalising the concept of Multi-Layer Safety (MLS). This approach distinguishes between three layers and corresponding measures: protection (through primary defence measures such as dikes and storm surge barriers), prevention (through flood resilient spatial planning and configurations) and preparedness (through crisis- and disaster management). This three-fold approach provides the Netherlands with a sound and comprehensive strategy to keep our feet dry. In theory.

In practice, however, problems are arising. The Dutch National Delta Programme of 2019 concluded that the efforts towards more resilient spatial planning (the second MLS layer) are currently insufficient. Essentially, this master thesis asks the question what reasons for this insufficiency are. The central research question therefore is: "What are the barriers and opportunities for resilient spatial planning in flood risk management?". By addressing this question, this thesis aims to contribute to more resilient spatial planning and management concerning flood risk. Scientifically, it aims to bridge the often perceived gap between theory and practice concerning the MLS concept.

The emergence of the MLS concept can be placed inside a wider transition visible in Dutch water management over the past decades, in which a new water paradigm emerged: from a resistance-based strategy, towards a risk-based strategy in which water resilience is the key word. Socio-ecological resilience can be described as the ability of systems to change, adapt and transform in response to stresses and strains (Davoudi, 2012). Over recent years there is a growing consensus that resilience has four important components: persistence, preparedness, transformability and adaptability.

On the basis of these four components, this thesis scrutinized the presence and absence of flood resilient spatial planning in two cases: Dordrecht and the IJssel-Vecht Delta. The presence of second layer measures, instruments and strategies was summarized in FRSPI models. By comparing both cases, this thesis aimed to contribute to the development of indicators of resilience. On the other hand, also the absence of flood resilient spatial planning was investigated, including the underlying reasons for this absence. Results from the analysis of both cases are in line with conclusions of the Delta Programme (2019): there is a large difference between the wide array of measures and strategies that are possible in theory, and those that are actually realized in practice. This large gap between theory and practice is the result of an extensive list of persistent barriers attached to many of the second layer measures. This thesis identified three spatial-physical barriers for flood resilient spatial planning: deep maximum flood depths (1), a lack of space (2), and rigidity of the pre-existing built environment (3). Additionally, six institutional-organizational barriers were found: a false, low or non-existing safety perception or risk awareness, and therefore a lack of urgency to act (4), a lack of political and societal support (5), a suboptimal collaboration between important stakeholders resulting in an imbalance between integration and a sectoral approach (6), ambiguity and uncertainty regarding responsibilities (7), finance and the (temporal) cost-benefit imbalance of second layer measures (8), and a lack of human capital (9).

Subsequently, this thesis explored possibilities to breach these barriers, as by doing so it can contribute to the progression of the embodiment of more resilient spatial planning to flood risk, and could bridge the often perceived gap between what is theoretically possible and what is executed in practice. Although difficult, the institutional-organizational barriers are surmountable. The spatial-physical barriers are on the other hand more problematic to breach, hence they form the most important restrictive factor for the opportunities for the second layer of the MLS approach. This thesis concludes by exploring where flood resilient spatial planning can be (most) successful, given these barriers and opportunities. By doing so it takes stock and explores the future of the second layer of the MLS concept.

List of abbreviations

C5a	Cluster for Cloud to Coast Climate Change Adaptation
FRM	Flood Risk Management
FRSP	Flood Resilient Spatial Planning (the second MLS layer)
FRSPI	Flood Resilient Spatial Planning Indicators
GCM	Group Coordination Meeting
MIRT	Meerjarenprogramma Infrastructuur, Ruimte en Transport
MLS	Multi-Layer Safety
NSR	North Sea Region
PBL	Planbureau voor de Leefomgeving

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1 | Introduction

1.1 | Background

Deltaic and coastal regions all around the world are facing major challenges. On the one hand they face global climate change, sea-level rise, and increasing extreme natural events such as floods and droughts (Van der Voorn et al., 2017). On the other hand it is exactly these coastal regions that are predominantly urban, and experience high urbanisation rates, hosting both the largest and the fastest growing cities. Many of these regions are flood prone and vulnerable to extreme flood events (Seto et al., 2013). Both the impact and likelihood of severe flood event have globally considerably increased over the past decades, and the previously described changing conditions are expected to drastically exacerbate this trend in the years to come (Zevenbergen et al., 2013). "Developing climate change adaptation strategies in urbanised coastal regions is a major challenge, due to the large uncertainties of climate change" (Van der Voorn et al., 2017).

Also the Dutch delta anno 2019 is in the face of major uncertainties. Over recent decades, the political and public attention to water related issues is growing due to both the implications of global climate change and the intensification of coastline activities (Van Baars & Van Kempen, 2009). Trends of population growth in coastal zones, rising sea level, land subsidence, more extreme weather events, increasing social and economic capital at stake, is turning the Netherlands into a vulnerable place (Hidding & Van der Vlist, 2009). Especially, considering the country's low-lying topology: more than 60% of its territory is located in flood-prone areas, of which 43% is actually located under the sea-level (PBL, 2010). The Netherlands therefore already has a long and rich history of its fight against the water.

As early as the ninth century, inhabitants of wet grounds of the North Sea coastal region and deltas of three major rivers (Scheldt, Meuse and Rhine) started building dwelling mounds and dikes, and land was reclaimed from the water (Woodall & Lund, 2009). Although growing in size and scope, flood protection measures taken in the Netherlands remained being sectoral and fragmented for many years. A game changer for Dutch water management took place in 1953, ushering the second generation of water management in the Netherlands. On a stormy night and morning on the 1st of February, a strong north-westerly storm, in combination with high spring tides, and the funnel-shaped morphology and shallowness of the North Sea, resulted in a peak surge of 4.55 meters above the normal sea level, overtopping and breaching dikes in Zeeland, the most south-western province of the Netherlands (figure 1). It resulted in 1,836 casualties and millions worth of damages (Gerritsen, 2005; Hall, 2013; 2015, Choi et al., 2018). The flood event and extensive aftermath clarified the flood control infrastructure was inadequate and induced extensive reflections of water management strategies. It was the direct cause of the execution of the first Delta Programme, which lays out measures and strategies to protect the Netherlands against pressing issues of both water quality and water quantity. This first Delta Programme was very much engineering-driven (Restemeyer et al., 2017), and the construction of the Delta Works as designed and implemented by the Delta Committee was central. Up to this date, the joint coastal dunes, dikes and storm surge barriers of the Delta Works have protected the Netherlands by the ongoing reinforcement of the flood protection system based on safety standards (Zevenbergen et al., 2013).

Figure 1: Archival images of the North Sea flood of 1953 (sources: ANP, 2013; Rijkswaterstaat, 2019, Watersnoodmuseum, 2019).

After the near-floods of 1993 and 1995, the Netherlands moved towards a new water management generation. Discussions about the acceptability of flood risk and the uncertainties of climate change led to the establishment of the second Delta Committee in 2009, and two years later the Delta Act got accepted in the Dutch Senate (Zevenbergen et al., 2013). The current Delta Programme of 2010 has a more adaptive and integrated nature and advises the national Dutch government on how to both ensure protection against floods and secure freshwater supply up to the year 2100, in the name of Adaptive Delta Management (Gersonius et al., 2015; Restemeyer et al., 2017). The new water management generation in the Netherlands is embodied by the transition from a technical, engineering, resistance- and reliability-based flood management approach towards a more integrated, holistic, systematic, resilience- and risk-based flood management approach (Woltjer & Al, 2007; Van Slobbe et al., 2013; Schoeman et al., 2014, Meyer, 2016, Forrest et al., 2018) characterised by projects such as Room for the River and the Sand Engine. "The Delta Programme can therefore be seen as an overarching organisation bundling resources and people working on water policy in the Netherlands" (Restemeyer et al., 2017, p.925).

A concept closely related to the resilient flood risk management approaches is that of Multi-Layer Safety (MLS). This concept was introduced in the Dutch National Water Plan of 2009 with the overall aim to improve the integration of spatial planning and emergency response into flood risk management (Gersonius et al., 2015). The MLS approach originated from the idea to better include the risk in terms of the consequences of a potential flood, rather than the sole focus on the probability of a flood, as was promoted in the EU Floods Directive of 2007. The MLS approach describes a set of flood risk management measures and instruments which can be subdivided into three layers: protection (i.e. to reduce the likelihood of floods to happen), prevention (i.e. flood resilient spatial planning) and preparedness (i.e. emergency- and crisis management) (Zandvoort & Van der Vlist, 2014; Kaufmann et al., 2016). This broad approach aiming to reduce flood probability and to reduce the consequences, it provides the Netherlands with a sound and comprehensive means to keep our feet dry. In theory.

1.2 | Societal and scientific relevance

However, how does the MLS approach manifest itself in practice? Dynamic adaptation strategies in flood risk management are used with increasing frequency in practice. Nevertheless, various scientific researches bring to light the troublesome gap between theory and practice, and state the importance of bridging this gap (Walker et al., 2013; Gersonius et al., 2015). Despite the broad theorising of the concept of MLS, in their research Kaufmann et al. (2016) found that water managers are uncertain about the practical applicability of the concept on a broader scale. One of the reasons for this is financial implications: the structural measures from the first protection layer are nationally financed via the Delta Fund, while the measures from the second prevention layer and third preparedness layer mostly rely on regional funding. The issue here is that on the smaller regional and local level there appears to be a lack in: (1) discourse structuration (the adoption of a discourse by a wide range of relevant actors); (2) discourse institutionalization (the solidification of the discourse into arrangements and organizational practices) and (3) the awareness of flood risk (Hajer, 1995; Kaufmann et al., 2016). This might be a very good reason why in its most recent Delta Programme (2019) the Delta Committee concluded that in the execution of the MLS approach there is much room for progression with regards to the second layer: the efforts towards more resilient spatial planning regarding flood risk is currently insufficient. This conclusion was in line with the Delta Programme of 2018, which contained a special Delta Plan on Spatial Adaptation (2018). Since 2010, there has been an increased focus on resilient spatial planning in the Delta Programme in response to growing flood risk. After a hopeful start, the progression quickly faltered. The current approach is not stimulating the involved parties enough to make this resilient spatial planning an inseparable part of policy, legislation and practice: it remains too non-committal, open-ended and free of obligations, resulting in major differences between regions and municipalities in their awareness, analysis and approach towards resilient spatial planning (Deltaprogramma, 2018).

With both the likelihood as well as the impact of floods increasing due to a multitude of both natural and anthropogenic changes, there is a growing urgency to act; more focused, more concrete, and more active. Also in those places where the risk is currently not inordinately acute, speeding up the transition towards more resilient spatial planning is desirable in order not to miss opportunities to create synergies (Deltaprogramma, 2018): "There are many opportunities for reducing flood vulnerabilities in the face of global change and the importance of integrating social and economic as well as technical approaches has now been widely accepted (e.g. Scheur et al. 2011)" (Zevenbergen et al., 2013, p.1219). The ageing of water- and flood protection infrastructure such as sluices and dams is worldwide a large – though acknowledged – problem (Hijdra et al., 2014). Nevertheless it provides a good opportunity and fertile ground for the adoption of technological innovation and flood resilience enhancing redevelopment (Zevenbergen et al., 2013).

The harsh and detrimental conclusions from the Delta Programmes of 2018 and 2019 that underlined the poor application of flood resilient spatial planning in flood risk management form the prime sources to substantiate the societal and scientific relevancy of this thesis. The aim of this thesis is therefore a twofold:

- Socially, it aims to contribute to the progression of the embodiment of more resilient spatial planning to flood risk.
- Scientifically, it aims to bridge the often perceived gap between theory and practice concerning the MLS concept.

1.3 | Cluster for Cloud to Coast Climate Change Adaptation (C5a)

The North Sea Region (NSR) forms no exception to the trend of increasing negative impacts of the deltaic pressures and challenges of the Anthropocene. Over the past decade a vast increase of specific climate change scenario assessments for the NSR have become available, contributing to improved future projections. The either directly- or indirectly climate change-induced effects for the NSR are "overall increases in sea level and ocean temperature, a freshening of the North Sea, an increase in ocean acidification and a decrease in primary production" (Quante & Colijn, 2016, p.175). However, from all those challenges, flooding appears to be the most significant: from now up to the year 2080 damages from coastal flooding are expected to increase from €1.9 billion up to €25.4 billion, and fluvial flooding damages from €5.5 billion up to €97.9 billion (Interreg[1], 2018). In combination with increasing population growth, urbanisation, resource depletion (Seto et al., 2013), and ageing flood protection- and water infrastructure (Hijdra et al., 2014), effectively and efficiently addressing flood risk and finding adequate solutions is a complex task and common challenge shared by all countries of the NSR that face these risks (Interreg[1], 2018).

This urgent and commonly shared characteristic of the issue provides a fruitful ground for international collaboration between the countries of the NSR. Interreg – one of the central instruments of the European Union to foster cross-border cooperation and collaboration through the funding of projects (Interreg[2], 2019) – therefore launched from the first day of the year 2019 a three year project under the name of 'Cluster for Cloud to Coast Climate Change Adaptation', in short C5a. This project builds upon seven existing Interreg projects (figure 2):

- "TOPSOIL: explores the possibilities of using the topsoil layers so solve water challenges
- CANAPE: is working on water management in peatland ecosystems and their climate effects
- CATCH: works on urban water management in midsize cities
- BEGIN: focuses on blue green infrastructure for larger cities to become climate resilient
- FRAMES: aims on increasing climate resilience by working on the multi-layer safety concept
- FAIR: focuses on flood defense infrastructure asset management and the related choices in adaptation
- BUILDING WITH NATURE: is an approach in which natural processes are used to strengthen our flood defences" (Interreg[3], 2018).

By combining these seven Interreg VB North Sea Region subprojects, C5a is developing an integral 'Cloud-to-Coast' adaptation approach that aims to deliver multifunctional and multi-sectoral solutions fostering flood resilience of the NSR on all four identified constituent systems: catchment (through i.e. BUILDING WITH NATURE, CATCH, TOPSOIL and CANAPE), coasts (through i.e. BUILDING WITH NATURE, FAIR, TOPSOIL, FRAMES), cities (through i.e. CATCH, BEGIN) and infrastructure network (through i.e. FAIR, FRAMES). By integrally combining these constituent systems and subprojects, C5a works towards a 'common language' in flood resilience and develops "a multi-beneficial, advantageous and resilient way of working on flood management from Cloud to Coast that can be applied in practice" (Interreg[1], 2018, p.1).

Figure 2: The seven subprojects of C5a (source: modified from Interreg[3], 2018).

1.4 | Research questions

This thesis is written in the first half of 2019, and during the months of April to July in combination with an internship at Rijkswaterstaat, Department of Flood Protection. This thesis is written under the umbrella of the Interreg VB North Sea Region '*Cluster for Cloud to Coast Climate Change Adaptation*' (C5a) project of the European Union. The C5a project consists of seven case studies, of which one is the 'Wantij Zone' in the Dutch city of Dordrecht. A potential case study area is currently taken into consideration as Rijkswaterstaat and other partners involved started to explore the IJssel-Vecht Delta. The aim of this master thesis is to contribute to this exploration by linking the C5a project to the contemporary discussion on the Multi-Layer Safety concept in flood risk management. What lessons can be learned from the Dordrecht case study regarding MLS? In this, the second layer of the concept (resilient spatial planning) will receive increased attention, in order to approach the central research question of this thesis:

"What are the barriers and opportunities for resilient spatial planning in flood risk management?"

The rich abundance of scientific jargon present in this research question, makes a range of subquestions unavoidable:

- What is flood risk, and how is it managed?
- How can we unravel the ambiguity of the concept of 'resilience'? What does it mean to be resilient (for the specific system at hand)? Are there indicators for being resilient?
- What does the Multi-Layer Safety concept, and its flood resilient spatial planning entail?
- What are the main barriers and opportunities for resilient spatial planning in flood risk management?
- How can we deal with those barriers and opportunities?

A broad understanding regarding these questions needs to be established in the theoretical framework before the central research question of this thesis can be addressed. A note regarding this central research question has to be made: due to the complexity and interrelatedness of the topic at hand, in no way it would be possible to construct an all-encompassing list of the barriers and opportunities of resilient spatial planning. Therefore, this thesis does not have the aspirations of achieving this. As stated earlier, the objective of this thesis is to contribute to the progression of the embodiment of more resilient spatial planning to flood risk – and therefore also aims to bridge the often perceived gap between theory and practice concerning the MLS concept – by investigating two cases (Dordrecht and the IJssel-Vecht Delta), and draw conclusions based on those two cases regarding the central research question.

1.5 | Reading guide

To conclude chapter 1 (Introduction), this final section will provide the reader with a short overview of what to expect in the subsequent chapters of this thesis. Chapter 2 constructs the theoretical framework which functions as the foundation of the thesis. From the start it adopts a broad perspective and describes the pressures and challenges of the Anthropocene for deltaic and coastal regions which are defined as complex-adaptive systems. From here it describes contemporary transitions in water management and scrutinizes the concept of 'resilience'. Chapter 3 provides the reader with a short chapter setting the policy- and geographical background. It introduces the concept of Multi-Layer Safety and shortly describes the two case study regions central in this thesis: the island and city of Dordrecht and the IJssel-Vecht Delta. Subsequently, chapter 4 describes the methodology used to execute this thesis. It explains and substantiates the research method, data collection and analysis. Chapter 5 provides the results of this primary data collection of this thesis. It looks into both the presence of flood resilient spatial planning (through the FRSPI model) but also the absence of it. The gap between both can be explained by a set of persistent barriers, as analysed and explained in the discussion (chapter 6). Ultimately, this chapter also looks beyond those barriers to possible solutions to breach the barriers, as it explores the opportunities for flood resilient spatial planning, before moving to the conclusions in chapter 7.

2 | Theoretical framework

2.1 | Deltaic pressures and challenges in the Anthropocene

Deltaic regions anno 2019 are worldwide under great pressure. Firstly, climate change and its related implications are indivertible. There is general consensus that sea level rise could gradually add up to an additional 77 centimetre by 2100 for 1.5°C of global warming, or 93 centimetre for 2.0°C of global warming (figure 3) (IPCC, 2018). Such a sea level rise results in moderate to strong effects on natural systems such as inundation and flooding, wetland loss, erosion, saltwater intrusion, and impeded drainage (Nicholls, 2015). Simultaneously climate change induces more extreme natural events with on the one hand more frequent and more intense periods of precipitation and cloudbursts (Restemeyer et al., 2015), and on the other hand more frequent droughts (Black et al., 2013). These direct and poignant consequences of global climatic change are already discernible: throughout the last century the absolute number of damaging floods has risen considerably (White, 2010). Climate change, global warming and the implications outlined above result in an expected increase of coastal, fluvial and pluvial flooding due to a higher direct flood level exposure, or indirectly, for example through the coastal erosion of marshlands (Van Veelen, 2016).

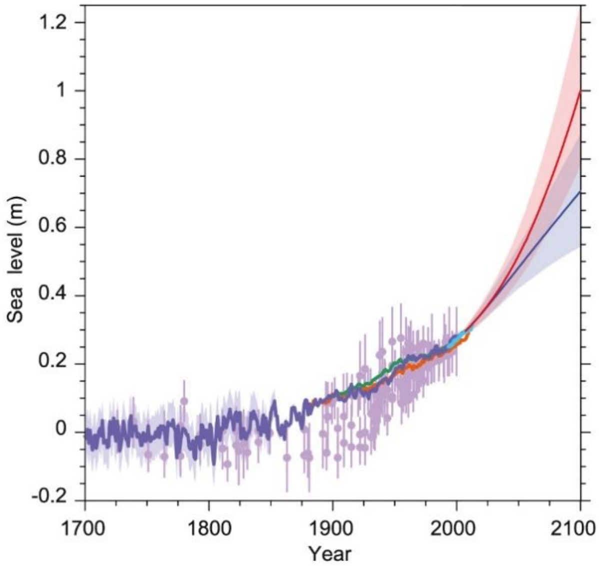

Figure 3: Mean sea level rise projections from 1700 until 2010, and projections up to 2100 (source: IPCC, 2013).

Deltaic regions anno 2019 are worldwide under great pressure, secondly, because a large share of the global population inhabits these low-lying deltas and coastal zones (UN-Habitat, 2013). Roughly half of the entire European population lives within a fifty kilometre reach of seas and oceans. These coastal regions therefore play a vital economic, cultural, social, and environmental role in society (De Jong et al., 2014). It are exactly these coastal and deltaic regions which are extremely vulnerable to the increasing flood risk due to the climate change processes described above (Van Veelen, 2016). Climate change is not the only factor for the increase of flood risk. Actually in a majority of cases, the primary cause for the increase in flood risk is land subsidence, often the result of excessive ground water withdrawal, drainage of marshlands and the process of ground settling (Meyer et al., 2010). A second reason for the increase of flood risk is the ever increasing urbanisation rate that can be observed globally, and especially in coastal regions. From 2010 to 2050 the absolute number of urban dwellers is expected to almost double, from 3.5 billion to 6.3 billion. Zooming in to the most vulnerable areas, it are especially coastal zones that are predominantly urban and home to the world's largest cities. Roughly 400 million people are currently living within a twenty kilometre reach of a coast, and this number is likewise expected to increase substantially (Seto et al., 2013). This continuous urbanisation increases urban flood susceptibility (Zevenbergen et al., 2008). In sum, expectations are that anthropogenic induced environmental changes, socio-economic developments, and (unplanned) urbanisation will exceed climatic change as the core reasons of an increasing flood risk in many global cities (Hallegatte et al., 2013). "In other words, the increase of risk in coastal cities is largely driven by urbanisation, changes in the natural landscape, increased sensitivity of economic activities and the accumulation of wealth in coastal areas, rather than the increase in flood levels" (Van Veelen, 2016, p.23).

Given the possible effects, this combination of on the one hand the natural – though often anthropogenic induced or aggravated – processes of land subsidence and climate change with its related implications, and on the other hand the geographical, economic, environmental and social importance of coastal regions therefore requires full and scrupulous attention. Schoeman et al. (2014) state that over the past decades, human-induced global change has become so ubiquitous that scientists increasingly argue that planet Earth arrived in a new geological epoch: the Anthropocene. Or as Latour (2017) calls it, a new climatic regime characterized by ecological mutation of an exceptional scale. It is the age in which increased levels of greenhouse gases, altered biochemical- and hydrological cycles and a substantial reduction in biodiversity rapidly accelerated global climatic change. Drivers of these biophysical changes are often associated with anthropogenic changes such as fast and exceptional growth, industrialization, mechanization and globalization (Schoeman et al., 2014). This led to the rapid increase of the physical extent of urban areas and populations, and therefore in a growing need for resources, which resulted in ecosystem (services) degradation (Seto et al., 2013). These characteristic pressures of the Anthropocene result in changing conditions, which are especially worrying for coastal regions. "The question is how to develop measures and strategies for existing urban coastal areas that can anticipate these […] changing conditions, such as gradually increasing sea levels and extreme river discharges" (Van Veelen, 2016, p.21). The Netherlands can be seen as a paragon of the issue outlined above: as the delta of three major rivers: the Rhine, the Meuse, and the Scheldt adjacent to the North Sea, where climate change will continue to pose a considerable risk of increasing sea-level rise, more fluctuating river discharge, and salinization problems (Van der Voorn et al., 2017), and where more than six million people live below sea level (Meyer, 2016).

2.2 | Background to complex adaptive systems

The pressures and challenges of the Anthropocene can be defined as a complex problem. A problem with a large number of influencing factors and variables which lack transparency, are interdependent, have cross-linkages, and consist of a large variety of possible goals and measures (Schönwandt et al., 2013). Another characteristic of complex problems – strongly relating to what was defined by Horst Rittel as 'wicked problems' (1972) – is the absence of a 'definite ending point' to such problems. Due to fundamental uncertainty, 'wicked problems' like climate change in urbanising deltas can never fully be 'solved'. The world is full of these wicked problems. Complexity influences the way in which planners interpret and intervene (Moroni, 2015). Processes such as technological innovation, climate change, sociological trends and economic fluctuations are evolving non-linearly and therefore unpredictable: context is volatile (Duit & Galaz, 2008; Rauws et al., 2014).

The development of climate change adaptation strategies in urbanised coastal and deltaic regions such as the Netherlands is difficult. Both because of the structural uncertainties related to climate change (Van der Sluijs et al., 2010), and because of the complexity and interconnectedness of both the social- as well as the ecological system in such areas. "These systems are complex, self-organising, unpredictable and non-linear in their response to interventions, which further complicates predicting and assessing future exposure to climate change" (Van der Voorn et al., 2017, p.520). Next to complexity and uncertainty, other characteristics of climate change adaptation are multiplicity and contentiousness. 'Multiplicity' describes the multi-faceted nature of the issue of climate change resulting in heterogeneous consequences. 'Contentiousness' describes the controversial character of climate change adaptation measures as a result of the uncertain and long-term character of climate change (Van Buuren et al., 2013). Taking this into account, the socio-ecological systems of coastal and deltaic regions can be defined as complex adaptive systems, characterised by non-linear development, contextual interferences, self-organisation, and coevolution (Rauws et al., 2014). In recent years, increased attention to the causes at core of the vulnerability and the flood risk of urbanised coastal and deltaic regions has indicated the large amount of subsystems of such regions and their mutual cross-linkages and interdependencies (Dammers et al., 2014). Complex adaptive systems, like the Dutch delta, are on the one hand influenced by external pressure such as climatic change, global warming, urbanisation and demographic change. On the other hand, they can be influenced by internal pressure: for example the interplay and the interventions of the agents within the system (Van Veelen, 2016). The functioning of paradigms, strategies, approaches and measures in such complex adaptive systems is depending on a seemingly paradoxical dichotomy: they need to be both robust and flexible. Robust because some degree of certainty is necessary for political and economic basis and support. Flexible because they need the ability to respond to changes in the complex and uncertain world they are manifested in (Rauws et al., 2014).

2.3 | Resilience in water management

Zooming into the complex adaptive system of urbanised coastal and deltaic regions, where climate change adaptation strategies play out, a reoccurring concept is 'resilience': one of the prescribed remedies for dealing with living in challenging times of uncertainty and unpredictability (Davoudi, 2012). Overall, there is a growing recognition of the importance of the root causes for the witnessed growing flood risk and vulnerability increase: the ongoing urbanisation, land subsidence, and the vital economic, cultural, social, and environmental role of deltas. "Consequently, in response to climate change, it is likely to be most effective to adapt existing urban environments and urban assets, and promote flood sensitive behaviour in combination with prevention based approaches, aiming to improve the whole capacity of the urban system to deal with changing and more extreme conditions in the future. This approach is known as the resilience approach" (Van Veelen, 2016, p.13). Resilience is however a troublesome concept that requires further elaboration. There are a multitude of definitions and perspectives on resilience, as it is used in multiple fields of interest. First of all, how did resilience become a core goal to be pursued in water management?

2.3.1 | The rise of a new water paradigm

Over the past years the characteristics and effects of the Anthropocene have provoked a careful reflection and reconsideration of paradigms in water management. "A paradigm is a shared pattern of seeing and thinking about the world, based on socially maintained assumptions, values and practices" (Schoeman et al., 2014, p.378). Until approximately the 1990s, the guiding paradigm in water management, but also in planning in general, was positivistic, knowledge-based command-and-control management (Schoeman et al., 2014). It assumes 'predictable uncertainty': based on facts, uncertainty can be reduced, and a rational choice in management-alternatives could be made. Nevertheless, the pressures of the Anthropocene revealed the shortcomings of this conventional type of water management, as can be seen in figure 4 below.

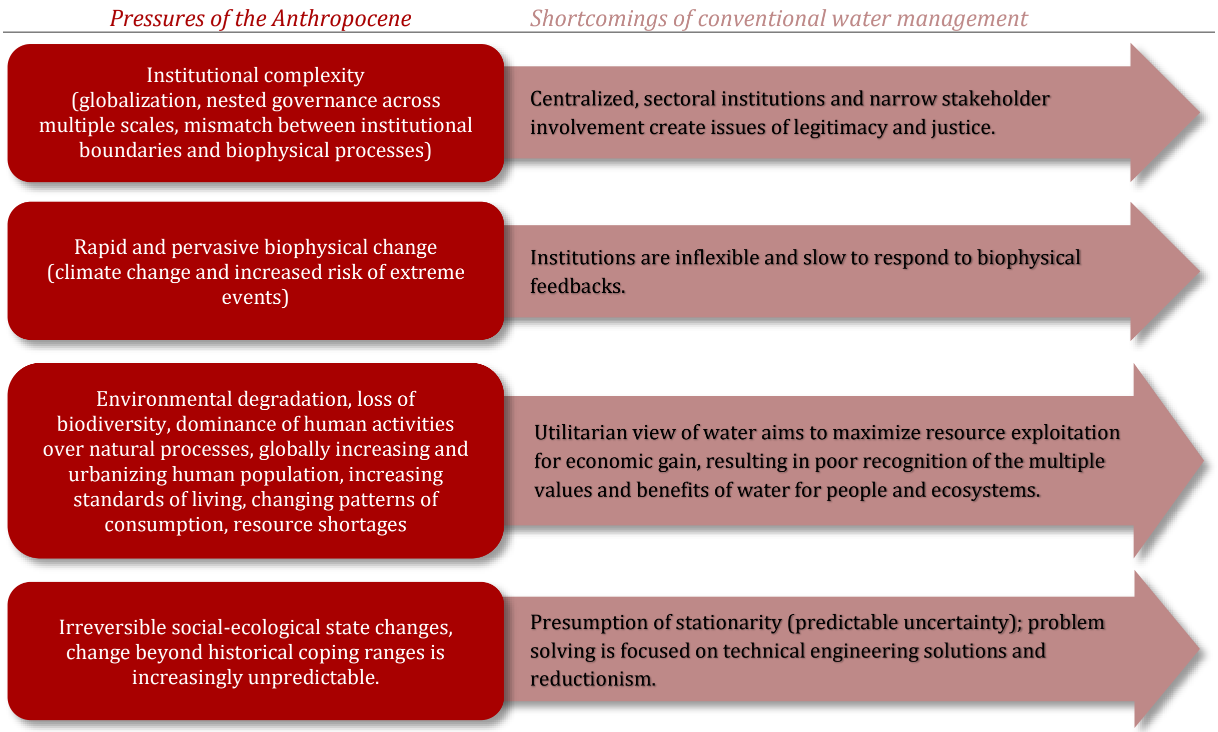

Figure 4: Pressures of the Anthropocene and the corresponding shortcomings of command-and-control water management (source: modified from Schoeman et al., 2014).

Around the 1990s' there was a growing recognition that solely using traditional flood control measures is an insufficient answer to the increasing risks and pressures of the Anthropocene (Restemeyer et al., 2015). Departing from the shortcomings of command-and-control water management as depicted in figure 4, a new paradigm in water management started to evolve since the 1990s, and is currently still developing. This new paradigm in water management, sometimes referred to as the 'new water culture' (Woltjer & Al, 2007), has high aims: "decision making aims for a broader spread of benefits for people and ecosystems through wider stakeholder participation; inclusion of different types of knowledge; attention to the human dimensions of management [...]; integration of issues, sectors and disciplines; and the desire to tighten the links between science, policy and practice" (Schoeman et al., 2014, p.379). Key differences between the 'old' and the 'new' water management style are given in table 1.

Old water management style (20th century)	New water management style (21st century)
Command and control	*Prevention and anticipation*
Focus on solutions	*Focus on design*
Monistic	*Pluralistic*
Planning-approach	*Process-approach*
Technocratic	*Societal*
Reactive	*Anticipative and adaptive*
Sectoral water policy	*Integral spatial policy*
Pumping, dikes, drainage	*Retention, natural storage*
Rapid outflow of water	*Retaining location-specific water*
Hierarchical and closed	*Participatory and interactive*

Table 1: The key aspects and differences of the transition in water management between the 20th and 21st century (source: Van der Brugge et al., 2005, p.173).

Many of the changes listed above are caught in the container concept 'resilience': a concept that rapidly gained currency over the past decades and in times of high uncertainty and predictability also nested itself in flood risk management. Generally, a dichotomy can be identified between resilience and resistance. Whereas the prime focus of a resistance strategy is to reduce the chance of a hazard magnitude to happen, resilience is more focussing on reducing the eventual effects of such a hazard magnitude. The resistance strategy is therefore strongly correlating to the 'keeping the water out' – mind set, with hard, grey, and technical measures at the core of the strategy. On the other hand, resilience correlates with the 'living with water' paradigm: - still technical measures are an inherent part of the strategy - however the possibility of a flood event is considered, and the strategy relies more on risk management instead of solely hazard control (Van den Brink, 2009; Restemeyer et al., 2015). Nevertheless, a very important note that needs to be made about resistance and resilience – and in that sense about the 'old' and 'new' water management style - is that they are not clear opposites. In fact, resistance can be seen as synonymous to robustness, being 'the power to withstand a hazard magnitude' (Restemeyer et al., 2015). Therefore, it can be concluded that the grounds for the identified dichotomy between resistance and resilience appear to be false. Resistance is still very much present within a resilience strategy. However, instead of being the core and sole focus of the strategy, resistance is now part of a broader strategy, known as resilience. The 'new' water management style is therefore not opposing, but supplementing the 'old' water management style.

Resilience departs from a so-called risk-based approach. As can be seen in figure 5, flood risk can be defined as the hazard probability multiplied by the consequences. Instead of solely focussing on minimizing hazard probability (resistance strategy), this risk-based approach addresses both sides of the equation: it aims to reduce flood probability *and* aims to minimize the consequences if a flood does occur (Van Veelen, 2016). Over the past decade the Dutch national Delta Programme adopted a new water safety-approach which translated this risk-based approach into national policy (Hoogwaterbeschermingsprogramma, 2019), which was a major step towards a more resilient water paradigm.

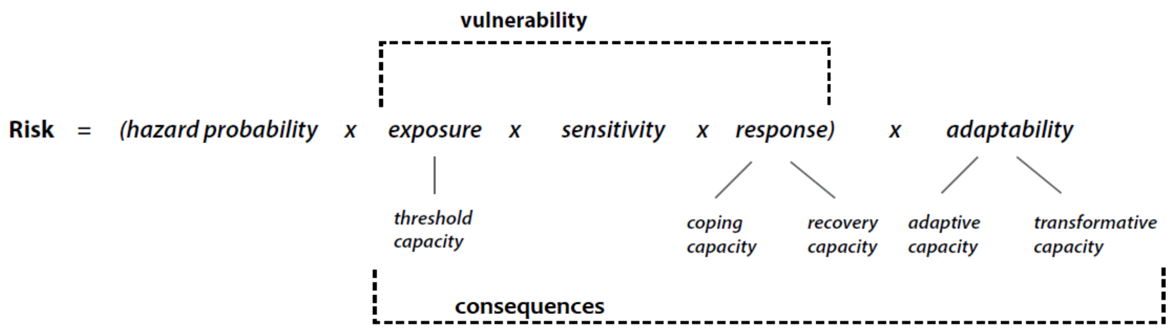

Figure 5: Risk-based approach formula (source: modified from Van Veelen, 2016, p.71).

2.3.2 | Resilience: buzzword or bridging concept?

The concept of resilience is troublesome due to overuse and ambiguity of its definition. Various authors therefore mark it as yet 'another buzzword', of which its malleability can justify many divergent measures. On the other hand, its popularity and extensive use also provide arguments to label it as a promising- and bridging concept in planning theory and practice (Davoudi, 2012; Davoudi et al., 2013). What becomes apparent from this dichotomy is that a careful use of the term is obligatory. What does 'resilience' entail?

Resilience derives from the latin word 'resilire' what literally means 'rebound'. Originally, this was exactly where the term was used for in mechanics and engineering resilience: to describe the ability or capacity to bounce back (Davoudi, 2013). This starting point is the vicinity of a stable equilibrium. After a stress or disturbance (engineering) resilience describes the ability of the system to bounce back to the original state. The focus is on recovery and constancy, and characteristics of engineering resilience are return time and efficiency (Folke, 2006).

In his pioneering article, Holling (1973) translated the term from engineering into ecological systems, as it described the "measure of the ability of these systems to absorb changes [...] and still persist (Holling, 1973, p.17). Ecological resilience therefore rejects the existence of one single equilibrium, but speaks of 'stability landscapes' with multiple equilibria: when stresses or disturbances force a system over a certain threshold, it can force the system into a new equilibrium. In the ecological resilience concept the focus is on persistence, robustness and the buffer capacity of a system to withstand a shock and maintain function (Folke, 2006). Ecological resilience can therefore be defined as "the magnitude of the disturbance that can be absorbed before the system changes its structure" (Holling, 1996, p.33).

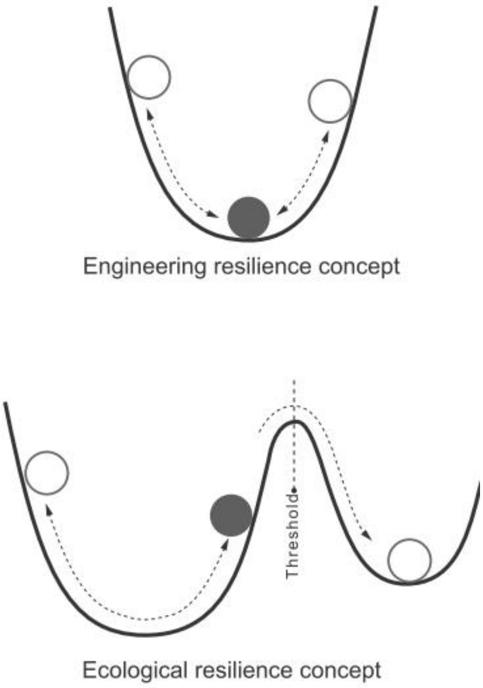

Figure 6: Conceptualizations of the engineering resilience concept and the ecological resilience concept (source: Soroushmz, 2016).

As can be seen in figure 6, a common characteristic of the engineering resilience concept and the ecological resilience concept is the idea of a stable equilibrium: a pre-existing state of a system in which it bounces back (engineering resilience), or bounces forth (ecological resilience) after a shock or stress (Davoudi, 2012; Davoudi et al., 2013). A major breaking point from this idea came with the introduction of the term resilience in describing socio-ecological systems. Such systems are complex, non-linear, self-organising and covered in uncertainty: complex adaptive systems. In such systems socio-ecological resilience – also called 'evolutionary' resilience – describes the "ability of complex socio-ecological systems to change, adapt, and crucially, transform in response to stresses and strains (Carpenter et al., 2005)" (Davoudi, 2012, p.302). This evolutionary perspective is therefore more dynamic, with a stronger focus on a systems' capacity to adapt and transform (Forrest et al., 2018). Holling and Gunderson (2002) depicted evolutionary resilience as a lemniscate in their panarchy model of adaptive cycles in which four phases can be distinguished (figure 7).

Whereas the engineering resilience concept and the ecological resilience concept start from the idea of a stable equilibrium, evolutionary resilience departs from integrated system feedback with cross-scale dynamic interactions. It is characterized by the interplay of disturbance, reorganization, sustaining and developing, with a focus on adaptive capacity, transformability, learning and innovation (Folke, 2006). Therefore, this evolutionary view of resilience resembles best the processes inherit in the functioning of complex adaptive systems (Spaans & Waterhout, 2017).

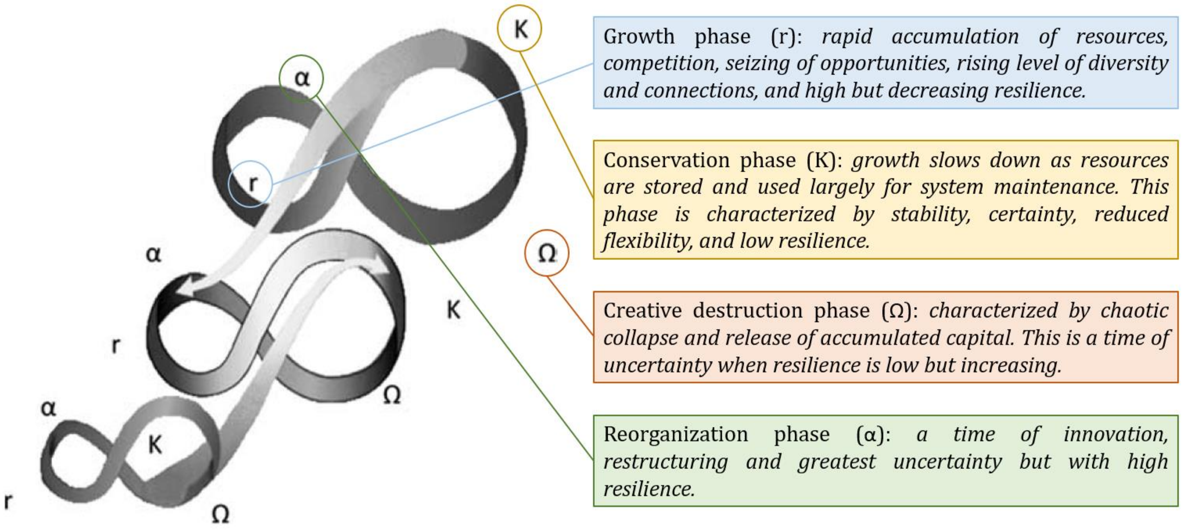

Figure 7: The panarchy model of adaptive cycles (source: modified from Holling & Gunderson, 2002; Davoudi, 2012).

2.3.3 | A framework for resilience building

The closing step that needs to be made is to investigate what the concept of (evolutionary) resilience means for flood risk management. In their article, Davoudi et al. (2013) follow Swanstrom (2008) by stating that "resilience is more than a metaphor but less than a theory. At best it is a conceptual framework that helps us think about processes such as climate adaptation in new ways that are more dynamic and holistic" (Davoudi et al., 2013, p.310). In building this framework we can distinguish between various indicators or characteristics of resilience. Above in section 2.2, it was described how coastal and deltaic regions can be seen as a good example of complex adaptive systems. Evolutionary resilience follows this notion, and also conceives such systems as being complex, non-linear, self-organising, and infused by uncertainty. Following this line of reasoning, resilience can therefore be defined as "the ability to remain functioning under a range of hazard magnitudes" (Gersonius et al., 2015, p.201). In their article Restemeyer et al. (2015) moved beyond "defining" resilience, to "doing" resilience, as the concept of resilience was converted into an operational framework. Following the reasoning of Galderisi et al. (2010), this was done based on three concepts out of which resilience is constituted:

- Robustness: can be defined as the power to withstand a hazard magnitude such as a flood, for example by building hard, technical defensive measures such as sluices, dams and dikes.
- Adaptability: entails adjusting the physical environment in such a way that – in the case of a flood event – the damage and disturbance is as small as possible.
- Transformability: this focusses more on the adjustments in the social- or institutional environment, or can be defined as a change in people's mind-set. For example the shift from a sectoral towards an integrated approach, or from 'fighting the water' towards 'accommodating the water' (Restemeyer et al., 2015).

This conceptual framework of Restemeyer et al. (2015) is to a large extend in line with the incorporation of the "dynamic interplay between persistence, adaptability and transformability across multiple scales and time frames in ecological (natural) systems" (Davoudi et al., 2013, p.310). However, the authors of the latter article advocate for the incorporation of a fourth component which better addresses the 'intentionality of human action and intervention': preparedness (Davoudi et al., 2013). These four components come together in the framework for resilience building (figure 8).

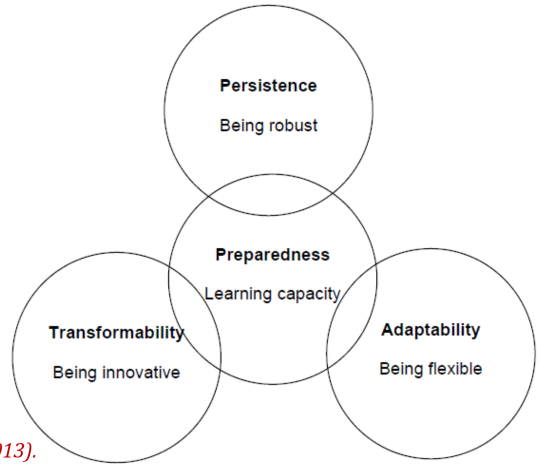

Figure 8: Four components for resilience building (source: Davoudi et al., 2013).

The four components mean:

- Persistence means to be robust: the power to withstand (Restemeyer et al., 2015).
- Preparedness is "humans' capacity for foresight and intentionality and their search for ways to enhance their ability to anticipate and plan" (Davoudi et al., 2013, p.314).
- Adaptability – or adaptive capacity – is the capacity of actors or objects in a system to influence resilience (Folke et al., 2010). Therefore it can be described as the flexibility of the system.
- Transformability is "the capacity to transform the stability landscape itself in order to become a different kind of system, to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Folke et al., 2010, p.3).

Following the reasoning of Davoudi et al. (2013), this four-dimensional framework for resilience building (figure 8) suggest that in the face of the deltaic pressures and challenges of the Anthropocene, complex adaptive socio-ecological systems – such as the city of Dordrecht or the IJssel-Vecht Delta – "can become more or less resilient depending on their social learning capacity (being prepared) for enhancing their chances of resisting disturbances (being persistent and robust), absorbing disturbances without crossing a threshold into an undesirable and possibly irreversible trajectory (being flexible and adaptable) and moving towards a more desirable trajectory (being innovative and transformative)" (Davoudi et al., 2013, p.311). This is the reason why this thesis draws on this framework to investigate and assess the flood resilient spatial planning plans of Dordrecht and the IJssel-Vecht Delta over the following chapters.

The rise of the 'new' water paradigm as described in paragraph 2.3.1 from a technical, engineering, resistance- and reliability-based flood management approach towards a more integrated, holistic, systematic, resilience- and risk-based flood management approach did not take place unnoticed. Not only in theory it received extensive attention (Meyer, 2016; Liao, 2014; Schoeman et al., 2014; Zevenbergen et al., 2010; 2013; Ten Brinke & Jonkman, 2009; Van der Brugge et al., 2005; etc.), but also in practice it clearly manifested itself. Flood prevention through hard, large scale infrastructural measures is increasingly seen as undesirable due to the recognition of their negative external ecological- and socio-economic effects. Moreover, these measures are not addressing the root causes of the problem behind the increasing flood risk, but merely address the symptoms (Pelling, 2011). These "traditional engineering approaches optimizing for safety are often suboptimal with respect to other functions and are neither resilient nor sustainable. Densely populated deltas in particular need more resilient solutions that are robust, sustainable, adaptable, multifunctional and yet economically feasible" (Van Slobbe et al., 2013, p.1461).

2.3.4 | Barriers and opportunities for resilience

As the previous sections illustrated, 'resilience' is a broad and 'fuzzy' concept with ambiguity regarding its specific definition. This fuzziness comes with advantages and disadvantages. On the positive side, resilience is a container concept that is able to unite perspectives, interests and opinions and therefore is capable of building a broad coalition that supports pursuing 'resilience'. On the negative site, this fuzziness and ambiguity results in confusion in terms of the process (*"What are we exactly planning for? Resilience to what ends?"* (Davoudi, 2012) but also in terms of the outcome (*"How resilient is a system? Can, and if so, how do we measure resilience?*). As 'resilience' is a system property, the latter is a key question. In attempts to circumvent this difficulty, scientific literature often diverts towards concepts such as 'adaptivity' and 'adaptive capacity' (e.g. Chapin et al., 2009; Hill & Engle, 2013; Whitney et al., 2017), which can be defined as the "ability of actors [...] to respond to, create and shape variability, change and surprise in the state of a linked socio-ecological system" (Hill & Engle, 2013, p.178). However, as this citation illustrates, this does not bring us much forward, as the question remains: how do you measure how a socio-ecological system reacts to events that have not happened yet? Furthermore, 'adaptivity' and 'adaptive capacity' are closely related to the concept of 'adaptability' – which is only one component of what 'resilience' entails in totality (Davoudi et al., 2013). Therefore, instead of getting lost in infinite terminological vicious circles it is key to move beyond 'defining resilience' to generate insights into 'doing resilience' (Restemeyer et al., 2015). Taking a more pragmatic viewpoint on concrete measures, instruments, objects or processes that hamper or foster resilience might help us forward in the quest for resilience, and helps to remain close to the central research question of this thesis. What can be understood as barriers and opportunities for resilience?

Various authors such as Harries & Penning-Rowsell (2011), Jeffers (2013) and Leichenko et al. (2019) elucidate an important and often occurring barrier to resilience. This barrier is rooted in institutional and legal cultures in which engineering ('old' water paradigm) responses to climate hazards such as floods are favoured over resilient, integrated ('new' water paradigm) approaches (Leichenko et al., 2015). The barrier described above shows clear signs of path dependency and a 'lock-in situation'. "A lock-in can be defined as a situation in which sub-optimal solutions persist because they have materialised in the physical, as well as the social, environment; lock-ins result from 'path dependence' which means that the flexibility of a system is limited by how a system developed in the past" (Restemeyer et al., 2017, p.924). Further resilience constraining factors can be of a technological-, economic- or spatial nature: a lack of technology and innovation, money, or simply a lack of space can be a barrier to resilience (Adger et al., 2009). A last often reoccurring barrier to resilience is the relative 'weak profile' of climate change and flood risk management: issues on these topics are often ambiguous, contentious and hard to understand, while effects are diffuse and long-term (Zuidema, 2016). Concrete examples of how this 'weak profile' in flood risk management forms a barrier to resilience are the slow progression of sea level rise and the tendency of short term political thinking (Leichenko et al., 2015).

'Synergies' are the keyword regarding the opportunities for resilience. Adaptive- and integrative approaches accommodate environmental systems (Morrison et al., 2018) and allow for synergies between the reduction of flood vulnerability and social, economic and technological innovation and flood resilience enhancing redevelopment (Zevenbergen et al., 2013). Due to this, making use of synergies (*'meekoppelkansen'*) has been stressed as one of the seven key ambitions in the 2018 Delta Programme on Spatial Adaptation. Also Restemeyer et al. (2015) accentuates the importance of synergies, as it offers opportunities to create added value for an area. For this reason, "flood resilience should not be a separate policy, but integrated into a broader [...] agenda" (Restemeyer et al., 2015, p.59).

The examples of barriers and opportunities for flood resilient spatial planning as mentioned above illustrate the various shapes and forms those barriers and opportunities can take: they can be physical, spatial, economic, technological, or – and this is an important one – institutional. The latter is important because planning can be regarded as an institutional process (De Roo, 2014). In this process 'institutions' are central (Ostrom, 2014). They can be defined as the "collectively enforced expectations with respect to the creation, management, and use of urban space…" (Sorensen, 2015, p.20) "…that guide collective action based on laws, regulations, norms and habits" (Van Karnenbeek & Janssen-Jansen, 2018, p.403). Therefore, institutions are much more than the often presumed 'organizations': they are the 'rules of the game'; the formal (regulation, laws) and informal (norms and values) rules of human conduct that form and shape society.

2.4 | Conceptual framework

The literature and theoretical concepts mentioned in the theoretical framework for this thesis have a lot of relations and interdependencies. They therefore can be captured well in a conceptual- (or theoretical) framework, as illustrated in figure 9. Next to the fact that this conceptual framework can be consistently employed as a tool for the rest of the research, it also functions as a concise summary of the theoretical framework.

Figure 9 describes that in the current Anthropocene there are growing deltaic pressures and challenges due to both natural changes (e.g. climate change, sea level rise, increasing extreme weather events, land subsidence) and anthropogenic changes (urbanization, population growth, increasing capital at stake). This makes us increasingly vulnerable to floods and flooding (Seto et al., 2013; Van Veelen, 2016). The uncertainty and complexity around these issues poses wicked problems for the socio-ecological systems (complex adaptive systems) in such deltaic and coastal regions (Van der Voorn et al., 2017). Through climate change adaptation and the pursuit of (socio-ecological) resilience, we attempt to mitigate this increasing vulnerability (Davoudi et al., 2013). This pursuit is however not easy, and is often the outcome of barriers on the one hand, and opportunities on the other. Identifying these is important in establishing pathways to flood resilient spatial planning (figure 9).

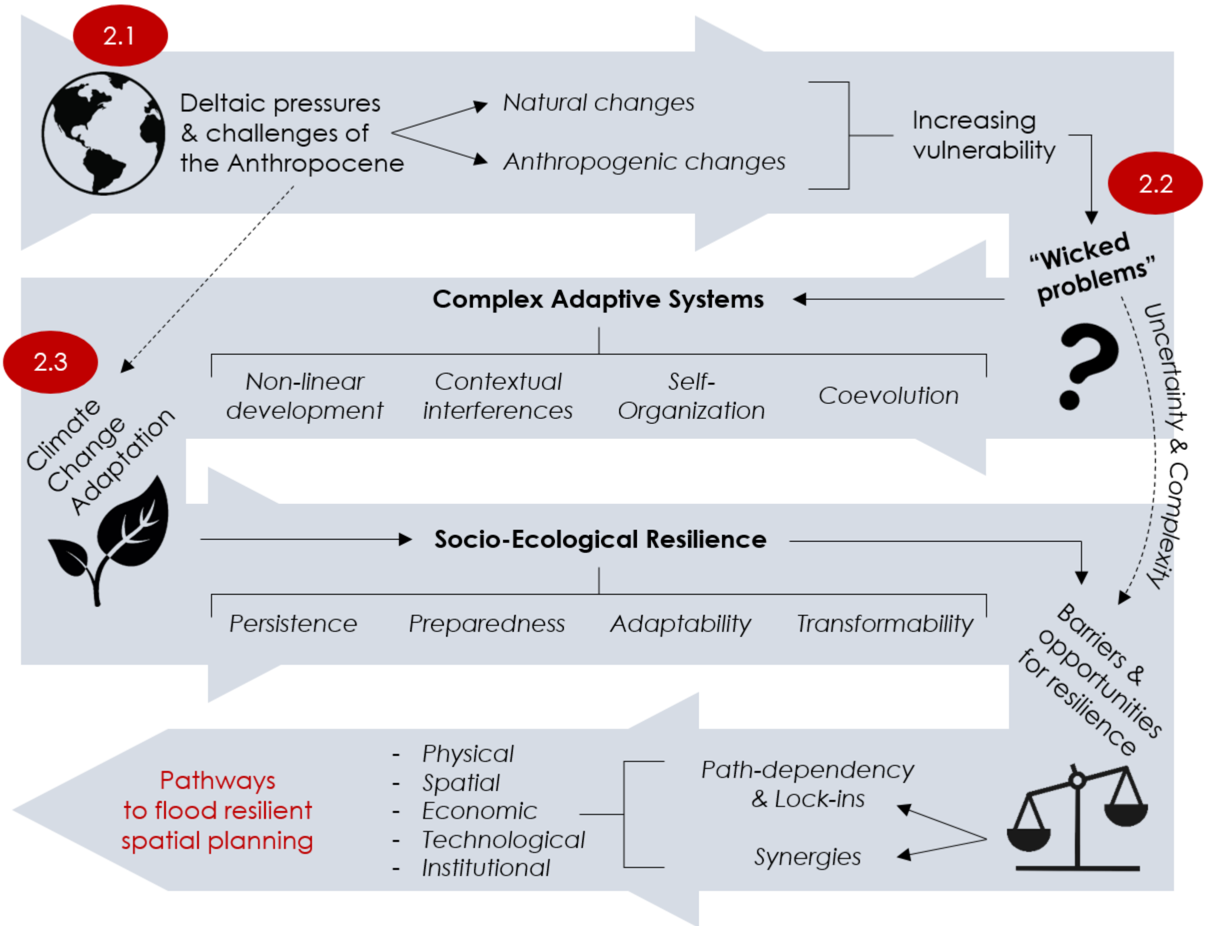

Figure 9: Conceptual framework (source: Author, 2019; based on the literature used throughout Chapter 2).

3 | Policy- and geographical setting

A final but essential part of the background framework that has to be mentioned before moving on to the methodology, result and discussion of this thesis, is establishing the policy- and geographical setting, as this is defining the world view in which this thesis is grounded (ontology). This short third chapter will connect the overarching national Delta Programme and its Multi-Layer Safety concept, to assess the lower scale application of the concept on the basis of the two central cases in this thesis: the island of Dordrecht and the IJssel-Vecht Delta.

3.1 | Multi-Layer Safety

The origin of the concept of Multi-Layer Safety (MLS) in Dutch national legislation and policy dates back to 2009, when it was introduced in the '*Nationaal Waterplan 2009-2015*' of the Dutch government as a means towards a resilient water management approach, taking into account the increasing flood risk and vulnerability (Ministerie van Infrastructuur en Waterstaat, 2009). There was general satisfaction with the efficacy of the concept, as it remained to be a core principle in the renewed six year plan which came into force in 2015. Therefore, the Dutch government continued applying a risk-based water management approach as the aim was to both reduce flood probability as well as to minimise the consequences of a potential flood (Ministerie van Infrastructuur en Waterstaat, 2015). As the name already suggest, the Multi-Layer Safety approach distinguishes between three 'layers' (figure 10), which jointly constitute an integrated water management approach:

1. Flood protection: The first layer is the primary pillar of the approach, and focusses on reducing flood risk probability through flood defense infrastructure – both artificial and natural (Restemeyer, 2019) such as dikes, dunes, levees, groynes, sluices, dams, breakwaters, and other infrastructural measures (Klostermann et al., 2014).

2. Resilient spatial planning: The second layer focusses on minimising the consequences of a flood by pursuing proactive spatial planning and flood-proof spatial designs (Restemeyer, 2019). Examples of measures that can achieve this are the compartmentalization of dike rings, the prevention of building in flood prone areas, and designing flood-proof designs for vulnerable functions such as schools and hospitals (Klostermann et al., 2014)

3. Crisis management: Also the third layer focusses on minimising the consequences of a flood, but here it tries to enhance the preparedness by updating and keeping-up-to-date the crisis management (Klostermann et al., 2014). This can be done through adequate risk communication (e.g. risk maps and communication plans) and adequate emergency response (e.g. early warning systems, disaster management, evacuation) (Restemeyer, 2019).

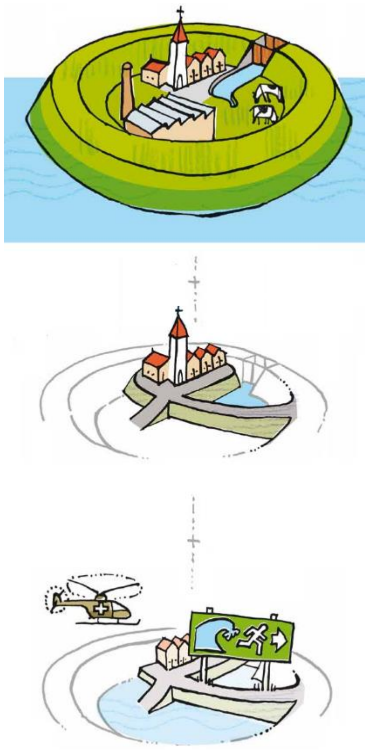

Figure 10: The Multi-Layer Safety concept (source: modified from Gersonius et al., 2015, p.210).

Currently, the focus in Dutch flood risk management has been mainly on reducing flood probability through flood protection (layer 1) with strong levees and dikes (Stive et al., 2011). Apart from this first layer, recently also disaster- and crisis management (layer 3) received increasing attention. Since 2010 the Netherlands has been subdivided into 25 different 'Safety Regions' (*Veiligheidsregio's*) who actively develop and maintain evacuation plans and scripts, and test them in flood disaster exercises (Klostermann et al., 2014). An eyesore that stays far behind is the flood resilient spatial planning (layer 2). Flood risk consequence-reducing measures through adequate spatial planning are barely considered in Dutch flood risk management. "The lack of measures in the field of spatial planning [...] portraits the current one-track approach, focused on reinforcing levees and dikes, instead of an integral risk reducing policy" (Leskens et al., 2013, p.2). This naturally brings to mind the question: how far are we actually in this broadly theorised shift towards a 'new water paradigm' as described throughout the theoretical framework of this thesis? In the most recent Delta Programme (2019) the Delta Committee had to conclude that in the execution of the MLS approach there is indeed much room for progression with regards to the second layer: the efforts towards more resilient spatial planning to flood risk is currently insufficient. How, and to what degree has the concept of Multi-Layer Safety found its way and manifested itself into the spatial planning and decision making on the lower administrative level? This question will be approached by scrutinizing two cases in more detail: the island of Dordrecht and the IJssel-Vecht Delta. Further case argumentation and justification can be found in section 4.1.

3.2 | The island of Dordrecht

The city of Dordrecht is located in the province South Holland, in the southwest of the Netherlands. More specifically, Dordrecht is located in the Rijnmond-Drechtsteden region; comprising of 1.6 million inhabitants and with the city and port of Rotterdam a key economic zone in the Netherlands, with international economic significance (Restemeyer et al., 2017). Surrounded by a multitude of rivers and canals, the 120,000 inhabitant of the city of Dordrecht are actually living on an island (figure 11). The seven hectares of land surface of this island comprise residential, industrial and agricultural areas. "The island of Dordrecht lies in the transition zone between the tidal reach and the river regime reach, where the extreme water stages are influenced by both the high river run-off and storm surges from the sea" (Gersonius et al., 2015, p.206). Add the influence and potential danger of precipitation and pluvial flood to this, and it becomes clear that adequate water management is an absolute exigency for the island of Dordrecht.

Figure 11: Aerial map of the island of Dordrecht (source: GroenBlauw, 2019).

The city of Dordrecht has operationalised Multi-Layer Safety in its flood risk management in the strategy plan '*Zelfredzaam Eiland*' (Self-Reliant Island) (figure 12). This strategy plan broadly has two aims. Primarily, it aims to keep the level of protection against flooding at the desired level by building on already existing preventive measures. Secondly, it aims to facilitate the self-reliance of the inhabitants of Dordrecht in the case of a flooding and by doing this, it aims to prevent societal disruption (MIRT, 2018). It tries to achieve this by a combination of primary water barrier differentiation, dike strengthening projects, the construction of a delta dike, and a tailor made infrastructural solution for the Voorstraat (layer 1), making optimal use of the available compartmenting dikes, flood proof construction of buildings outside the first compartment, and the increased attention to increasing robustness of vital infrastructure (layer 2), and a flexible evacuation strategy with clear evacuation routes, establishing shelters and safe-areas, and assuring the functioning of vital infrastructure (layer 3) (GroenBlauw, 2019). This threefold strategy is illustrated in figure 12. Back in 2014-2015, the main stakeholders (the municipality of Dordrecht, the water board 'Hollandse Delta', the province of South Holland, the Safety Region 'Zuid-Holland Zuid', the national Ministry of Infrastructure and the Environment, and Rijkswaterstaat) executed a MIRT-inquiry ('*Meerlaagsveiligheid Eiland van Dordrecht*') in which the '*Zelfredzaam Eiland*' strategy was established. Three years later another MIRT-inquiry ('*Operationalisering Meerlaagsveiligheid Dordrecht*') tried to elaborate and operationalise this strategy further (MIRT, 2018). Broadly the strategy can be divided into three categories, corresponding to a short term-, medium term-, and long term time scale. Under the short term – current – strategy, the prime focus is on the first layer of the MLS approach, as it comprises multiple dike- and storm surge barrier improvements and strengthening projects (Gersonius et al., 2015). This corresponds to the point of departure as established by the main stakeholders participating in the MIRT: flood risk prevention by investing in the first layer. Only in "specific situations" in which "smart combinations" can be made, there will be invested in measures that limit flood consequences through spatial planning (layer 2) or crisis management (layer 3), instead of conventional flood risk prevention measures such as dikes and storm surge barriers (MIRT, 2018). On various levels and in multiple configurations there are dialogues and assessments on how to achieve this: for example the 'City Deal Klimaatadaptatie', the 'Living Lab Zelfredzaam Eiland' and the 'Living Lab Ruimtelijke Adaptatie'.

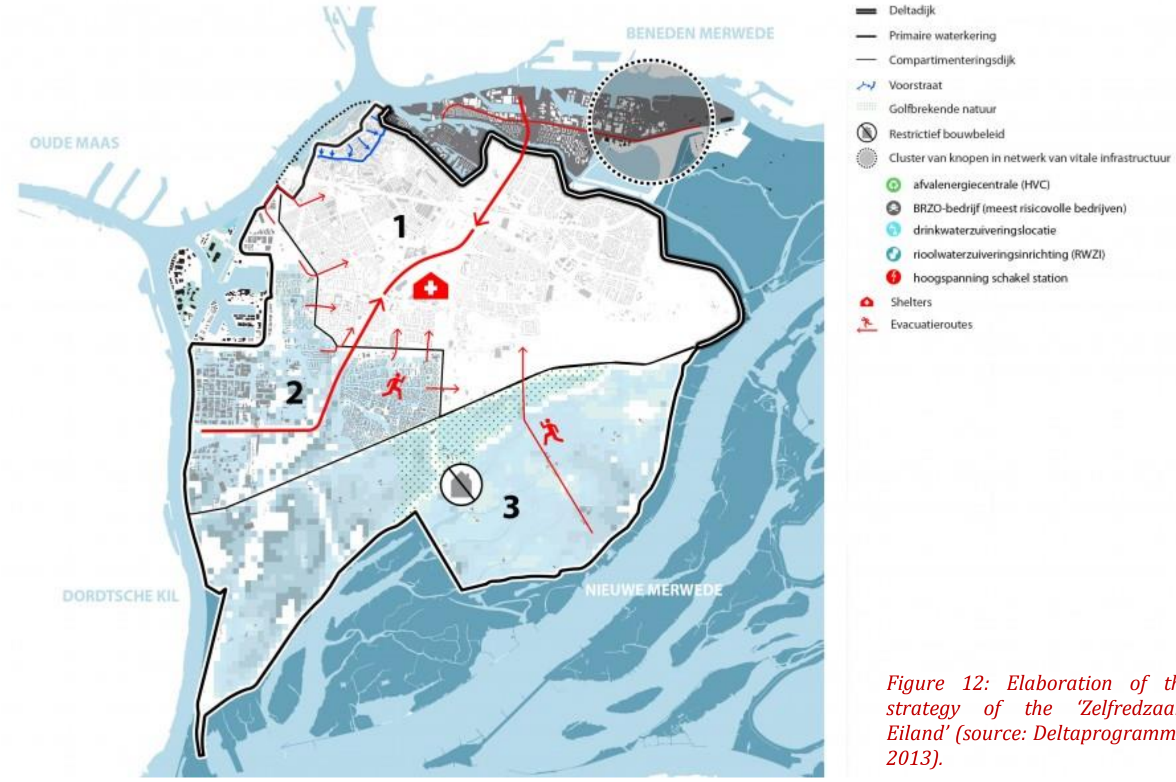

Figure 12: Elaboration of the strategy of the 'Zelfredzaam Eiland' (source: Deltaprogramma, 2013).

3.3 | The IJssel-Vecht Delta

The IJssel-Vecht Delta is an interesting, dynamic but also vulnerable region, influenced by various water systems, with in the west lake IJsselmeer and in the east the rivers IJssel, Vecht and Sallandse Weteringen (Blom, 2019). The region comprises of the municipalities of Zwolle (125,000 inhabitants), Kampen (54,000 inhabitants) and Zwartewaterland (22,000 inhabitants). Due to its dynamic and complex nature, the IJssel-Vecht Delta has been assigned as a focus point in the national Delta Program (Blom, 2019) as it was in need of increased attention to the flood risk of the region (Van den Brand et al., 2015). Apart from the moderately sized urban centres of Zwolle and Kampen, the IJssel-Vecht Delta is characterized by an open landscape with polder dikes (figure 13). The main land-use function of this region is grassland agriculture. Furthermore, the entire region serves important natural values as it is assigned as bird hotspot and is adjacent to important Natura2000 areas (WDO, 2016). After increased attention to climate change and the implications this poses for the region with more extreme weather conditions, increasing river discharges and more frequent droughts, the core stakeholders of this region (Province of Overijssel, water board Drents Overijsselse Delta, Safety Region IJsselland, and the municipalities of Zwolle, Kampen and Zwartewaterland) collaborated between 2011 and 2018 to jointly construct the Program IJssel-Vecht Delta, which aims to improve water safety of the region, and to make it climate robust (Blom, 2019).

Figure 13: Aerial map of the IJssel-Vechtdelta (source: Google Maps, 2019).

The Program and MIRT-inquiry IJssel-Vecht Delta aims to realize a sustainable, save and climate-proof IJssel-Vecht Delta by following the principles of the Multi-Layer Safety concept. Next to the island of Dordrecht, the IJssel-Vecht Delta has been assigned as a pilot of the operationalization of MLS. The inquiry led to recommendations on looking beyond solid infrastructural first layer MLS measures, and improving the coherency between measures regarding flood protection through dike reinforcements (layer 1), flood resilient spatial planning (layer 2), and crisis management (layer 3) (Van den Brand et al., 2015; MIRT, 2016). Reason for this was the adoption of the risk-based approach to water safety: the focus on both flood probability reduction as well as reducing the potential consequences. The stakeholders of the program acknowledged that investing in a mix of measures in spatial planning, water robust building and crisis management, additional to the safety provided by primary dikes and barriers, enhances the resilience of the region (Van den Brand et al., 2015). The largest innovation that the MIRT-inquiry brought about is the way in which stakeholders collaborate, as it focussed on uniting interests and concerns. This procedure led to numerous interesting and integral projects (MIRT, 2016), of which multiple have been summarised in figure 14.

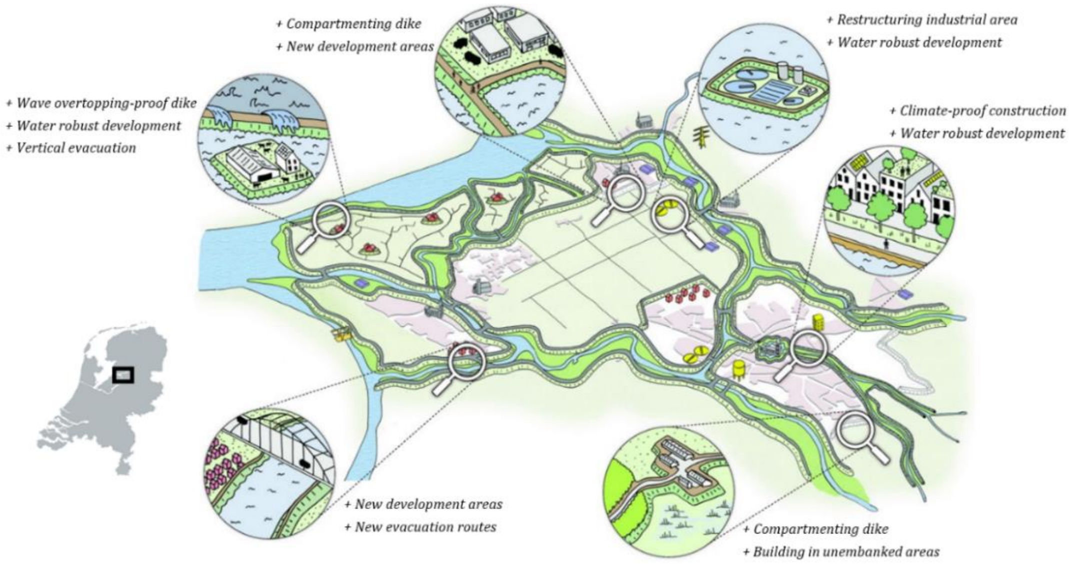

Figure 14: Overview of the IJssel-Vecht Delta and its major projects (source: modified from URHAHN, 2015).

4 | Research methodology

After establishing the world view in which this thesis is grounded (ontology) in the previous chapters, the focus in now on epistemology: how to acquire knowledge about the world. This third chapter describes the methodology used in this thesis. It describes the research methods, data collection, and data analysis process.

4.1 | Research methods and case justification

In essence, this thesis is based on qualitative case study research. The choice for qualitative research was made as this provides insights and helps understanding trends and relations in expert views and perceptions. Furthermore, with the central research question "*What are the barriers and opportunities for flood resilient spatial planning"*, this thesis has a rather exploratory nature, of which useful data is currently not expressed in numeric data. Therefore, quantitative research was less suitable. When specifying the research methodology in more detail, the most prominent characteristic is that this thesis makes use of multiple research methods and multiple data sources. In that sense, the methodology shows signs of triangulation, which can be defined as the process of using both multiple research methods as well as multiple information sources with the aim to maximize the understanding of a research question. For this reason, triangulation – the mixing of methods - is often desirable in scientific research (Clifford et al., 2010a). An important research method used in this thesis is the 'constant comparative method', which describes the constant cross-comparison of both primary data and secondary data (O'Leary, 2004). The type- and sources of these will be described in the following section.

Another important research method in this thesis is the comparable-cases strategy (Lijphart, 1975). The choice to execute a case study research was essential to delimit the scope of this research. As time and resources to carry out this master thesis were limited, the choice was made to geographically demarcate two case study areas: Dordrecht and the IJssel-Vecht Delta. These two cases were chosen in close consultation with Rijkswaterstaat. Again the limited amount of time and resources was an important determinant for the choice to scrutinise two (and not more) cases. Choosing for two cases still gives the researcher the opportunity to make comparisons, while delimiting the cases to two allowed the opportunity to scrutinize both cases really in depth, and not merely superficial, given the limited time. Based on this reasoning, the choice for a qualitative case study research, with two cases, was made.

Dordrecht has been an exemplar case for multiple Multi-Layer Safety studies ever since its first appearance in the '*Nationaal Waterplan 2009-2015*'. Furthermore, the Wantij Zone in Dordrecht is one of the seven case study areas of the Interreg C5a. Despite earlier theorization of this case, the choice to scrutinize this case again in this thesis was made as in Dordrecht the consideration of the MLS approach is already a given; hypothetically, íf there are already barriers and opportunities for flood resilient spatial planning, then many of them can be identified in this case. The second case study area suggested by Rijkswaterstaat was the IJssel-Vecht Delta. The initial hypothesis that justified the selection of this second case was that within this region, multiple small scale measures and plans related to the MLS concept can be found, however an overarching strategy is missing. Initially there was therefore aimed for a certain sequentiality in the two cases: first scrutinizing Dordrecht, and assess the resilience of the system of the IJssel-Vecht Delta on the basis of the findings from the Dordrecht case. However, early in the primary data collection process, the earlier mentioned hypothesis seemed to be false. In the degree and extend of operationalizing the MLS concept, both cases appeared to be much more commensurable than initially assumed. Therefore, this sequentiality was no longer adhered to: the IJssel-Vecht Delta has no longer been investigated on the basis of the case of Dordrecht. Rather, both cases have been analysed independently, and have no mutual accordance until section 6.1, in which both cases will be confronted with each other, in an effort to work towards universal indicators of resilience. Based on the latter, the two case studies can be regarded as complementary to each other, and useful lessons potentially can be drawn after the analysis. Based on the assessment of these two cases with help of the FRSPI model, an answer to the central research question of this thesis is formed: *"What are the barriers and opportunities for resilient spatial planning in flood risk management?"* This question is therefore answered by making use of both inductive and deductive research. Deductive as this thesis draws on previously executed scientific research on spatial adaptation to flood risk, to assess two cases. It is however also inductive as it is generating understanding from the data itself (Clifford et al., 2010b).

4.2 | Data collection

Not only the research method of this thesis is characterised by triangulation, but also the data and their sources. Using a wide variety of sources and data types strengthens scientific results (Clifford et al., 2010b): substantiating results by the consultation of numerous and various sources safeguards the reliability of results (Cope, 2010). This thesis makes use of both primary data and secondary data. Secondary data – "information that has already been collected for another purpose but which is available for others to use" (White, 2010, p.61) – is an indispensable source of data. The majority of secondary data in this thesis is originating from previously executed scientific research and literature, and important policy documents, such as the most recent Delta Programme. Primary data was mainly collected during a three months long internship at the lead beneficiary of the Interreg C5a project: Rijkswaterstaat. Apart from the attained knowledge and data as a result from attending and assisting project conferences and meetings with the project leaders, two main primary data sources can be distinguished:

- Nine in-depth expert interviews have been executed over the course of April and May 2019. Suitable interviewees were chosen on the basis of their specific topic related knowledge, competencies and expertise and/or their position and direct involvement in relevant projects. The functions of the interviewees vary: they are operating as (policy) advisors in water management, water safety and spatial planning, and are either privately-employed, or employed by municipalities, provinces, and water boards. Interviewees were either found independently or suggested by C5a project leaders of Rijkswaterstaat. From the nine interviewees, three are directly associated to the case of the island of Dordrecht. Likewise, three interviewees are directly related to the case of the IJssel-Vecht Delta. The remaining three interviewees are involved with flood risk management, and consequence reduction on a higher administrative level. Due to the confidentiality and anonymity, no names and further details of the interviewees can be given. The interviews have been executed in a semi-structured fashion in order to allow the interview to proceed in a conversational way, so that important aspects and topics can be explored in more detail (Longhurst, 2010). Results from these interviews form the core of the results (chapter 5), while full interview transcripts can be found in the appendices.

- The second primary data source originates from a workshop given on the 21st of June 2019. On this day the preliminary results of this thesis were presented on the Coordination Group Meeting of the Interreg C5a project in Ringkøbing, Denmark. Additionally to an introductory presentation, a workshop was organised with the audience (international beneficiaries of the C5a project from various NSR countries). After presenting the barriers of flood resilient spatial planning which were acquired in an earlier stage of the primary data collection, three specific questions have been discussed in an interactive manner: *"How could these barriers be breached? What are (related) opportunities for flood resilient spatial planning?"* and "*What aspects or results from my research would foster your Cloud-to-Coast approach?"*. Results of this workshop have been used in the discussion (chapter 6) and recommendations (chapter 7) of this thesis.

4.3 | Practical and ethical considerations

Some practical and ethical considerations had to be made during the data collection process, following the universal etiquette of scientific research. The principles of ethical behaviour such as justice, beneficence, non-maleficence, respect, consent, confidentiality, harm, and cultural awareness (Hay, 2010) have been and will be closely followed. Dissemination of results and feedback to thesis participants such as interviewees and supervisors will be adhered to before, during and after the research. Participants were allowed to withdraw themselves from this research at any time. Permission to digitally record the interviews and/or Team Meetings was asked prior to the event, and explicit consent to use information, names and citations was established, following the principles of anonymity and confidentiality (Longhurst, 2010). All interviewees have signed an Informed Consent form prior to the interview. This can be found along with interview guides and transcripts of the interviews in the appendices. Of course, also critical remarks concerning this thesis (e.g. regarding methodology and positionality) can be made. This aspect will be addressed in the reflection on this thesis (section 7.2).

4.4 | Data analysis

The interviews have been recorded, and the results were transcribed afterwards. This data was then analysed by making use of qualitative, descriptive coding. Such a code can be a word or a short phrase that captures the gist of a section of the data. Such a descriptive code identifies the topic of an answer, not the content of the answer (Saldaña, 2016). By doing so, coding helps to identify patterns, structures and categories in the cumulative primary data that is collected (Cope, 2010). This thesis makes use of a combination of both axial coding (in which certain categories will be made prior to the interview – based on key concepts in literature from the theoretical framework) and open coding (in which the categorization of codes will be done while analysing the interview results, based on the reoccurrence of key themes and topics). Axial coding and open coding have proven to be complementary to each other and is a much favoured coding technique (Strauss, 1987). The final coding table can be found in the appendices.

4.5 | Building the FRSPI Model

Based on the primary information of the interviews, workshop and internship meetings, and the secondary information from scientific literature and important policy documents, the flood resilience of the spatial planning of the two case studies was assessed, as from here barriers and opportunities of flood resilient spatial planning were identified. In order to do this as structured and transparent as possible, this thesis attempts to develop indicators of flood resilient spatial planning by developing the Flood Resilient Spatial Planning Indicator (FRSPI) model. In doing so, it draws on the findings of Davoudi et al. (2013) and Restemeyer et al. (2015). In the FRSPI model three layers can be distinguished (figure 15) with in the core the flood resilient spatial planning of the investigated system (in this thesis these are the city Dordrecht and the IJssel-Vecht Delta): dimensions, resilience components, and indicators (or targeting issues).

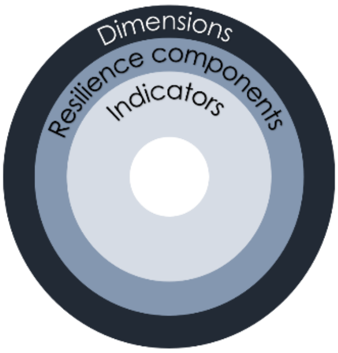

Figure 15: The basis of the FRSPI model (source: Author, 2019).

Each of these layers have (multiple) subdivisions (figure 16):

1. The first layer distinguishes between various dimensions. These dimensions can be technological, economic, institutional, spatial, etc. In order not to rule out important categories, no initial a priori categorizations will be made.
2. In relation to all the identified dimensions, the second layer represent the components of resilience as described in the scientific literature of e.g. Davoudi et al. (2013) and Restemeyer et al. (2015). It distinguishes between four components: persistence, preparedness, adaptability and transformability.
3. The third layer identifies the indicators that illustrate the presence/absence of the resilience components in the flood resilient spatial planning of the investigated system, distilled from the expert interviews. Initially these indicators will be predominantly 'targeting issues' (concrete strategies, measures, plans, approaches, instruments, etc.). Later in section 6.2 an attempt will be made to translate these targeting issues into real indicators of resilience.

Fundamentally, this thesis therefore adopts a threefold stepwise approach.

1. It takes Dordrecht / IJssel-Vecht Delta as study objects (cases) and considers both as complex adaptive system.
2. Via primary data (expert interviews) and secondary data (literature and policy documents) research it identifies dimensions (e.g. institutional, spatial, technological, physical, economic) and corresponding targeting issues and indicators (e.g. concrete measures, instruments, strategies, activities, etc.) of the presence or absence of resilient spatial planning in flood risk management.
3. By analysing and comparing those two cases, important barriers and opportunities for resilient spatial planning in flood risk management can be distilled. (An important note here is that this generalization of 'universal' barriers and opportunities will be done at the basis of only two cases; a limitation of this research that will be further addressed in section 7.2.)

Identifying these barriers and opportunities could provide us with pathways to resilient spatial planning in flood risk management.

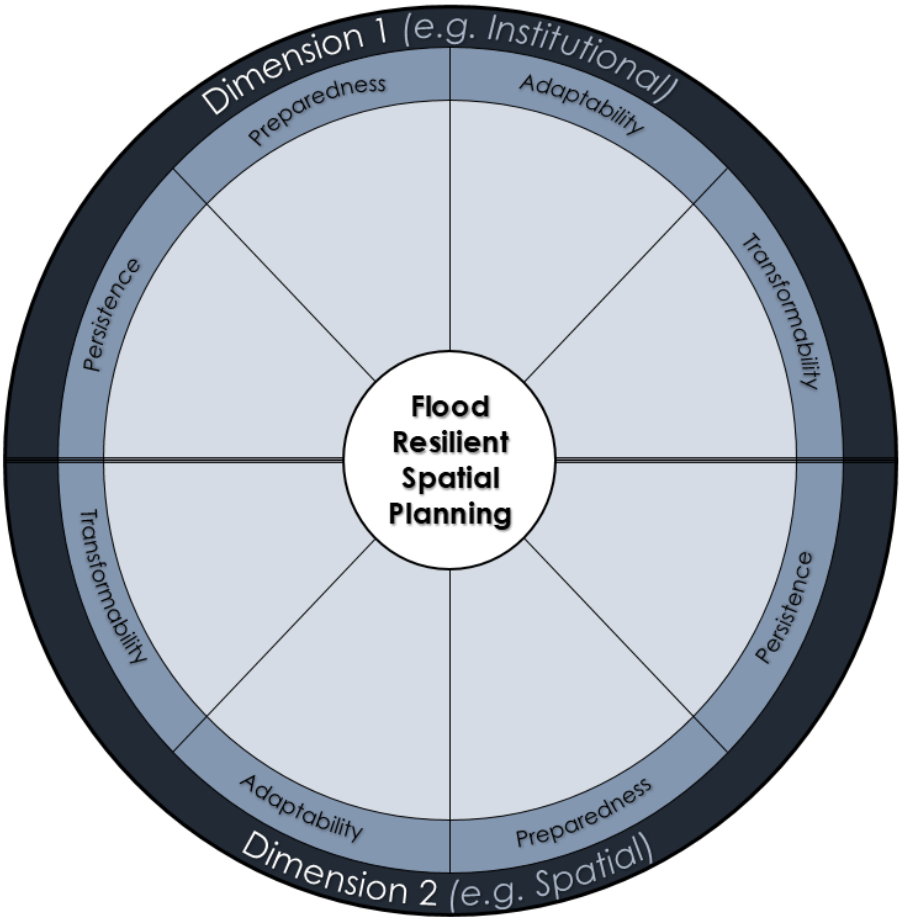

Figure 16: The Flood Resilient Spatial Planning Indicator (FRSPI) Model (source: Author, 2019).

The biggest dilemma and choice that had to be made in the development of the FRSPI model was either to approach the methodology more inductively or deductively. In an inductive style, the thesis would generate understandings or theories from the data itself (Clifford et al., 2010b). This would mean that the FRSPI model would be left open as much as possible and would not predetermine dimensions, components and indicators of resilience: everything would result from the primary data collection. Following a deductive style would mean that a predetermined theory would be guiding and potentially a hypothesis would be tested (Clifford et al., 2010b). This choice would mean that the FRSPI model would be filled in more: dimensions, resilience components and indicators would be chosen prior to the primary data collection. Accordingly primary data would be categorized under these predetermined dimensions and indicators. The choice between such an inductive- or a deductive research methodology was far from easy as there are major advantages and disadvantages to both methods. A deductive method would be better able to frame the research into a specific direction and testing primary data along 'universal' indicators of resilience and would potentially make cases better comparable. However, is it really possible to distil and generate such 'universal' indicators for resilience from the literature? And even if they eventually are acquired, then how do you measure the degree to which those indicators are established in the system at hand? The comprehensiveness and ambiguity regarding the term 'resilience' makes this deductive method close to impossible to pursue. Moreover, specifically pick-and-mixing predefined dimensions and indicators runs the serious risk of an a priori exclusion of potential crucial dimensions and indicators.

Because both options provide solid arguments, a mix between the inductive and deductive method was finally chosen for: the components of resilience follow deductively from scientific literature (persistence, preparedness, adaptability, transformability) (Davoudi et al., 2013; Restemeyer et al., 2015). The dimensions and indicators follow inductively, directly from the primary data. Nevertheless, an important note to be made is that the spatial- and institutional dimension will receive a slight focus, following the background and education of the researcher and author of this thesis.

5 | Results

This chapter is a straightforward presentation of the results of the expert interviews. To categorize this chapter, it has been divided into three sections. The original coding tables of each of the three empirical analyses can be found in appendix 2.10. *Please note that the results of the workshop are addressed in the discussion (Chapter 6).*

5.1 | Empirical analysis of Multi-Layer Safety

This first section analyses the three expert-interviews of the interviewees which are involved in flood risk management, and consequence reduction on a higher administrative level: interviews 3, 4 and 5.

5.1.1 | Resilience and Multi-Layer Safety

The theoretical background described the difficulty of the conceptual ambiguity regarding resilience. This is the reason why a core objective of the Interreg C5a project is to work towards a ‘common language’ regarding resilience and affiliated topics. For this reason every interview started with the question what ‘resilience’ entails for the interviewee, to ensure a congruent wavelength and common starting point for the rest of the interview. Interviewees 3 and 5 directly translated ‘resilience’ to the Dutch words “*weerbaarheid*” and *“veerkracht*”. It entails to what degree, when something happens, a system is capable to withstand an external force, and how quick the system can recover (Interview 3, 2019). In a certain way, it describes the vulnerability of a system. It is both a physical matter, but also an institutional and organizational matter. How good is the system prepared? (Interview 4, 2019). Applied to flood risk management, resilience is a step further than just persisting, as it looks further than reducing the flood probability, but starts from the idea that floods can never fully be ruled out. Therefore it is all about consequence reduction (Interview 5, 2019). A resilient city would be a city that would incorporate water (safety) comprehensively throughout all its new developments: a city that is able to develop without increasing its own flood risk and vulnerability (Interview 5, 2019).

Although in several instances the terms ‘persistence’, ‘preparedness’, ‘adaptability’ and ‘transformability’ were not directly brought up by the interviewees themselves, they all agreed that aspects of these are part of resilience. Relating concrete measures and strategies, let alone actually realized measures and strategies, to these four components was generally perceived being difficult. “There simply are not a lot of concrete measures, strategies and instruments within this second layer. This already elucidates the problem of this second MLS layer a bit…” (Interview 4, 2019).

Nevertheless, ‘persistence’ was by the interviewees quickly translated into ‘robustness’. Of all four components of resilience, examples of persistence enhancing measures were relatively the least difficult to find for the interviewees, despite the conceptual ambiguity in which also this ‘robustness’ is covered (Interview 5, 2019). The most mentioned measure was the compartmenting of dikes, dividing dike rings into subsections, preventing a full dike ring to flood at once (Interview 4, 2019). Although directly downsides of such dike compartmentalization were also mentioned, as for some areas such dikes in fact increase the consequences of a potential flooding (Interview 5, 2019). Furthermore, the elevated construction of environments was mentioned as a potential persistence enhancing measure of flood resilient spatial planning (Interview 4, 2019). When discussing MLS measures on the level of private properties, the distinction between dry-proof (ensuring water does not enter a building e.g. through such elevated construction) versus wet-proof (minimizing damages when water does enter the property) was made (Interview 5, 2019). The latter can be reached by water persistent building regulations (Interview 4, 2019). When talking about persistence and robustness, all three interviewees still strongly emphasized the importance of first layer measures. Because the best consequence reducing measure “is preventing the flood from happening in the first place” (Interview 3, 2019). Interviewees expected that the continuous investments in primary dikes and storm surge barriers to safeguard robust primary flood defence measures will remain the focus point of the Dutch water management strategy for the upcoming years (Interview 3, 2019; Interview 4, 2019). We need to secure the maximum safety that this primary MLS layer offers us (Interview 5, 2019). Second and third layer measures should be regarded as additional, not as replacements.

However, additional does not necessarily mean less important: sixty percent of the Dutch land surface is prone to flooding, so increasing the awareness and preparedness towards water disturbance and floods – e.g. through second and third layer measures - is more than sensible (Interview 4, 2019). In establishing such additional measures, ‘preparedness’ is mainly about how well people are prepared for water disturbance and flooding, therefore mainly corresponding to third layer measures of MLS (Interview 4, 2019). Interviewee 3 distinguished between ‘resilient areas’ (which describes persistent and robust systems through primary dikes and dams) and ‘resilient communities’ (which describes the ‘social resilience’ of which awareness and preparedness are key aspects). “Especially the latter requires major advancements here in the Netherlands” (Interview 3, 2019). The first MLS layer is generally very well arranged in the Netherlands, but stakeholders and the general public are largely unaware of the opportunities regarding what such communities can do themselves to mitigate the effects of floods and water disturbance. Especially for private companies there are opportunities: for example a few simple preparations can prevent thousands of euros of damage (Interview 3, 2019). Furthermore, stimulating this private uptake of preparedness enhancing arrangements and measures can relieve the scarce evacuation and disaster management capacity of governments in times of floods and flooding (Interview 3, 2019). The ‘preparedness’ component clearly illustrates the thin line between the second and third layer of the MLS approach. The empirical analysis of the interviews illustrate the partial similarity of both layers: spatial planning for flood risk management and elevated environments foster ‘preparedness’ and crisis management (the third MLS layer), but are examples of flood resilient spatial planning, and thus second layer measures (Interview 5, 2019). With regards to severe flooding with deep flood depths, it is for example crucial for adequate crisis management that there are sufficient and accessible elevated safe zones and evacuation routes. According to interviewee 5, currently, congestion remains one of the largest vulnerabilities of crisis management and evacuation strategies (Interview 5, 2019).

The interviewees had more difficulties describing adaptability and transformability (although ‘flexibility’ was regularly used), and presenting examples of measures and strategies that belong to these components of resilience. These components were also considered as being one and the same thing. ‘Adaptability’ was found in the flexibility of parts of the system with a multi-use function. The Van Benthemplein and the parking garage under the central station of the city of Rotterdam were mentioned as examples. Both are examples which enhanced the water storage capacity of the city, although under normal conditions fulfilling another function (Interview 3, 2019). Such examples of flood resilient spatial planning aimed at water disturbance is beginning to become common good and ground in the Netherlands (Interview 3, 2019). ‘Transformability’ was mentioned in relation to the development of long term visions in which you incorporate flood risk into future spatial planning, despite the uncertainty of climate change and future developments (Interview 5, 2019). Furthermore, ‘transformability’ is all about a certain tipping point of a system: prior to when the risks in a system are growing beyond manageability, it is important to consider long term visions for that system (Interview 3, 2019).

5.1.2 | Barriers for flood resilient spatial planning

However, there is a big difference between the wide array of measures and strategies of flood resilient spatial planning possible in theory, and those realized in practice. Many of them are labelled (as observed in the expert interviews, see paragraph 5.1.1) as being additional, on top of the first layer measures, and rather long term ambitions. Therefore, actually realized examples of flood resilient spatial planning are scarce (Interview 4, 2019). This gap between theory and practice is the result of an extensive list of persistent barriers attached to many of the second layer measures. The most reoccurring barrier mentioned by the three interviewees was the financial barrier. To put it short: in most cases, the benefits of the second layer simply do not outweigh the often voluminous costs (Interview 4, 2019). The relatively well-arranged, strong and robust primary protection layer of dikes, dams and storm surge barriers provide most parts of the Netherlands with a very low flood probability. Especially when the probability of a flood is low, it is very expensive to selectively protect single or multiple objects within a system. In most cases, it is more cost-effective and efficient to protect the entire region (system) including each and every object with first layer measures. “This is probably the reason why barely anything happens in this second layer”(Interview 4, 2019). Not only the construction of second layer measures seems more expensive, but additionally also the long term maintenance. “All those extra costs have to be made for an event that might never happen. On an administrative level, this is very difficult to justify” (Interview 5, 2019). For these additional measures of the second and third MLS layer, there is only a limited amount of money available. This limited amount of money then has to be shared between all aspects of climate change adaptation: so next to floods and flooding, it is also used for mitigating heat and drought related problems (Interview 5, 2019). Another important aspect with regards to the financial barrier, is the delayed return of benefits. Investments in flood resilient spatial planning have direct costs during the construction phase, but benefits will only become apparent after a few decades. "As administrations often have a limited budget to work with, which has to be divided between climate change adaptation, housing, education and health care, second layer measures for the long term often simply do not have priority" (Interview 3, 2019).

The financial barrier can be seen as a part of a wider set of institutional barriers. Next to the lack of money, also ambiguity regarding responsibilities can be seen as an institutional or organizational barrier to flood resilient spatial planning (Interview 5, 2019). "Whereas the first MLS layer has clear divisions in responsibility, the second layer concerns more actors and stakeholders, and barely no arrangements have been made with regard to their mutual responsibilities" (Interview 4, 2019). When more actors and stakeholders are involved, differences in interests, objective risk perception, safety perception, and therefore urgency to act, is unavoidable (Interview 3, 2019). Already the practice of water safety of engineers and effect reduction of spatial planners are sometimes two separate worlds. Whereas engineers are focussed on meeting standards in the *'Hoogwaterbeschermingsprogramma'* from now up to 2050 via the construction of dikes and dams, spatial planners and effect reduction has a much longer time scale (Interview 5, 2019). However, whereas the discussion of climate change adaptation is starting to become a common practice on the administrative level, it is even more difficult to find common grounds with those stakeholder that are not involved in water safety issues on a daily basis, such as private companies and the general public (Interview 3, 2019). "The underlying lack of awareness is another huge barrier for flood resilient spatial planning. You can try all you want, but without awareness you are flogging a dead horse" (Interview 5, 2019). Another institutional barrier is that policy in the Netherlands generally is very short term. "Every other four years there is a different government with different councillors. There is simply not the constant type of policy that climate change adaptation requires" (Interview 4, 2019). A final institutional-organizational barrier mentioned by the interviewees was the fragile basis of human capital involved in climate change adaptation. Often, it is in the hands of a few people: (the lack of) enthusiastic people therefore make-or-break successful policy (Interview 4, 2019). Sufficient human capital has to be present on every administrative level, but remains to be scarce (Interview 5, 2019).

Next to the above mentioned institutional barriers, also different kind of barriers were given by the interviewees. "Flood resilient spatial planning is very much dependent on the type of development: whether this concerns new development or re-development of a pre-existing built environment. Furthermore, it is very much dependent on the depth of the water during a flooding" (Interview 5, 2019). This citation touches two essential spatial-physical barriers to flood resilient spatial planning. Due to the rigidity of the built environment, it is always difficult to transform this into a system that is more water resilient (Interview 3, 2019). Since the Netherlands is already rather 'fully built', there is a lot of this rigidity and a simple lack of space for large scale second layer measures (Interview 4, 2019). Furthermore, just like dikes, most of the second layer measures have a maximum capacity of water they can persist or accommodate. A maximum flood depth of two metres is fairly common throughout the Netherlands. A water blocking baseboard in front of doors, or a meter high dwelling mound are then simply not sufficing. "For such deep floods flood resilient spatial planning is a rather hopeless story" (Interview 4, 2019).

5.1.3 | Solutions and opportunities

However, a complete write-off of the second MLS layer is out of the question: "When flood probability would have been higher, or when second layer measures can be linked to other developments in the region, so it does not cost extensively more money, then there are definitely opportunities for flood resilient spatial planning" (Interview 4, 2019).

When discussing solutions to breach the barriers, awareness was mentioned as a starting point. There needs to be awareness about the fact that we are never completely safe: there is always a risk of flood. This awareness and urgency needs to be deeply established both administratively, in private companies and in the general public (Interview 5, 2019). Since the general public plays a crucial role in the success or failure of climate change adaptation strategies, they are stakeholders that need to be involved early in the decision making process: it increases their awareness and therefore preparedness to make the required long term investments (Interview 3, 2019). Therefore, increasing awareness and urgency is also the first step towards solving the financial barrier (Interview 3, 2019). A means to generate this deeply required awareness and preparedness, is the existence and usage of good examples (Interview 5, 2019). “Especially for the second MLS layer, I see an opportunity to start a risk dialogue with stakeholders and the general public to enhance this awareness. In the Netherlands we tend to think in big infrastructural projects, where the society and communities could do so much themselves. There is so much potential out there, ready to be snatched” (Interview 3, 2019).

Furthermore, a lot of the costs can be reduced when the climate change adaptation measures are linked to other developments in the region, looking for synergies: ideally a project developer should already incorporate measures in his plans and projects (which again requires more water awareness). This approach would already cut down a lot of the additional costs (Interview 5, 2019). “Fundamentally, this returns to the entire point of ‘transformability’. We should move towards a world in which climate change adaptation has been fully adopted in long term spatial visions and plans. That every new development takes flood risk into account, and flood resilient spatial planning is linked as much as possible to other developments in the region. We should approach this as a long term process. This is not something that we can fix tomorrow” (Interview 5, 2019). The existence and rigidity of the pre-existing built environment could still form a barrier to this, however “despite the fact that it may not look like it, spatial planning in the Netherlands is continuously changing. We can achieve so much if climate change adaptation can move along with these developments” (Interview 5, 2019).

Despite the maximum flood depth being a persistent barrier to flood resilient spatial planning measures, this does not mean that by definition second layer measures cannot mitigate the consequences of floods at all. First of all, there are enough regions in the Netherlands with a flood depth below a meter. The balance between costs and benefits for these shallow floods is already better aligned, and flood resilient spatial planning has definitely potential here (Interview 4, 2019). Secondly, a deep maximum flood depth does not directly imply that every flood or flooding will reach this maximum. “When you focus on these shallow floods through flood resilient spatial planning, a lot of the consequences can already be reduced. This is very effective” (Interview 5, 2019). A focus point where flood resilient spatial planning could be most effective, and where therefore opportunities for this second MLS layer are, concerns the vital infrastructure, such as drink water supply and electricity (Interview 4, 2019).

Despite the above, limits to the solutions and opportunities also came to light: “I simply do not know a lot of examples where this second layer has been successful. This indicates the problem: If flood resilient spatial planning would have been really auspicious and promising than we definitely would have seen more examples over the past ten years. Maybe we just have to admit that the opportunities are simply limited. If at all there are opportunities, then they should be sought for in regions with shallow maximum flood depths, high flood probability, new developments, and we should then start applying it to our vital infrastructure” (Interview 4, 2019).

5.2 | Empirical analysis of the island of Dordrecht

This second section analyses the expert-interviews directly involved in the case of Dordrecht: interviews 1, 2 and 8. Additionally, Dordrecht-related extracts from interviews 3, 4 and 5 have been used if possible and relevant.

5.2.1 | Resilience and Multi-Layer Safety in Dordrecht

The term ‘resilience’ was described by the interviewees as the question how you deal with future uncertainties, which is an extremely difficult task (Interview 1, 2019). The conceptual ambiguity was recognised, but generally described as the degree to which people, organizations and systems are able to withstand disturbances, and how quick they can recover from it (Interview 8, 2019). Applied to flood risk management, ‘resilience’ tells you something about how well a system can cope with extreme events such as floods. It is about reducing damages, and if that is not possible, then how quickly and efficiently a system can recover. “It is often in close combination with adaptation: climate change adaptation measures enhance resilience” (Interview 2, 2019).

According to the interviewees, the island of Dordrecht is already pretty advanced in their move towards a Multi-Layer Safety approach. “In Dordrecht there is a broad awareness of its own spatial characteristics of being an island: in times of flood, evacuation options are limited and there needs to be a large degree of self-reliance” (Interview 5, 2019). This demands for a careful consideration of flood risk in Dordrecht (Interview 4, 2019). “With regard to the second layer in this approach, it is about two aspects: location choice and spatial lay-out and configurations” (Interview 2, 2019). The first consideration and no-regret strategy with regards to location choice is to ensure that vulnerabilities and valuables are located at a higher elevation: “don’t place your data centres in basements” (Interview 1, 2019). The stresstest – as developed in the Delta Plan on Spatial Adaptation (2018) - is an already existing instrument in identifying those vulnerabilities and valuables. An interesting choice specifically for the island of Dordrecht with regard to location choice, is the potential of the unembanked outer-dike area called the Wantij Zone. “I am a large proponent of building in that area, because it paradoxically is a safer location than many of the embanked areas of the city, because it is located on higher grounds. This area has the potential to become a super shelter: we call it Noah´s Ark” (Interview 2, 2019).

‘Robustness’ was mentioned by the interviewees as being a part of resilience (Interview 1, 2019). Flood resilient spatial planning could enhance this robustness or persistence of a system through deploying a set of preconditions to new developments that comprehensively incorporate flood risk into new development. The city of Dordrecht is currently developing such preconditions for water disturbance, heat stress, droughts and water safety. Such preconditions can be seen as a set of performance requirements that (new to build) objects and aspects in the system have to adhere to. An example of such a precondition is the legal obligation that each private property and garden should have the capacity to accommodate a minimum of twenty millimetres of precipitation (Interview 8, 2019). Larger scale, public green-blue infrastructural measures have also been considered and assessed (Interview 1, 2019). Further examples of these preconditions can be found in the covenant ‘*Klimaat Adaptief Bouwen’*, which explored and implemented water blocking baseboards in front of doors, the obligation to have skylight windows to prevent people from being trapped in their attics in times of a flooding (Interview 2, 2019), and persuades people to place stone tiles on the first floors of their houses instead of wooden laminate (Interview 3, 2019).

For the latter to take flight, awareness and preparedness is key. “Everything begins with generating awareness. This is the first step, and requires a continuous dialogue about climate change, and linking this to current events. Dordrecht is very active in this” (Interview 1, 2019). Awareness is raised through organizing a dialogue between the local government of Dordrecht and her inhabitants, in which the municipality always tries to provide action perspectives what citizens can do themselves to mitigate the consequences of floods and flooding, for example green up gardens or prepping emergency kits. “This awareness is definitely growing” (Interview 8, 2019). In their strategy, this second component of resilience – preparedness – receives a lot of attention, since Dordrecht in general strongly focusses on crisis management and generating sufficient and accessible shelters and safe zones (Interview 5, 2015).

According to Interviewee 8, the final two components of resilience – adaptability and transformability – are mainly about the extent, speed and degree to which the administrative system is able to change and adapt to new developments. “It is however very difficult to give a value and judge this, because how can you measure that?” (Interview 8, 2019). However, the interviewees directly involved in the island of Dordrecht, showed no consensus regarding these two components of resilience. In fact “resilience can be seen as an opposite of transformability: in order to transform you need to break through the resilience of a system. It is all a matter of scale in which you address such issues” (Interview 2, 2019). The mutual difference between adaptability and transformability can be found in the fact that “adaptation is often an incremental modification to foster resilience. Transformation however is a considerable change towards a different system” (Interview 2, 2019). A crucial question for the interviewees in the light of this ‘transformability’ is whether or not it is still possible to live in the West of the Netherlands. This question goes beyond consequence reduction, and is currently not considered well enough (Interview 1, 2019).

5.2.2 | Assessing resilience: Dordrecht in the FRSPI model

The main share of the instruments, strategies, measures and means of flood resilient spatial planning as discussed in the section above are still concepts: ideas of which the feasibility is currently investigated or just an ‘ideal prospective’ envisioned by the planners and policy advisors of the island of Dordrecht. Concrete examples of such strategies and measures that are in place at the moment are very limited. Therefore, for establishing the FRSPI model below, both categories are taken into consideration: executed and/or future plans.

After investigating the flood resilient spatial planning (layer 2) of the island of Dordrecht, two dominant dimensions for the FRSPI model resulted from the primary- and secondary data analysis: an institutional-organizational dimension, and a physical-spatial dimension. Subsequently, the degree of resilience is assessed following the four components of resilience (persistence, preparedness, adaptability and transformability) as described in chapter 2. What follows can be described as targeting issues, that could potentially guide us towards 'indicators of resilience'. It is important to stress once more that these targeting issues and indicators are not an all-encompassing summation of flood resilient spatial planning. Figure 17 only presents the most reoccurring results distilled from the primary and secondary data analysis. Supplementary to the FRSPI model of the island of Dordrecht (figure 17) is an explanatory table including a short explanation for each indicator as derived from the interview results. This table can be found on the next page and onwards in table 2.

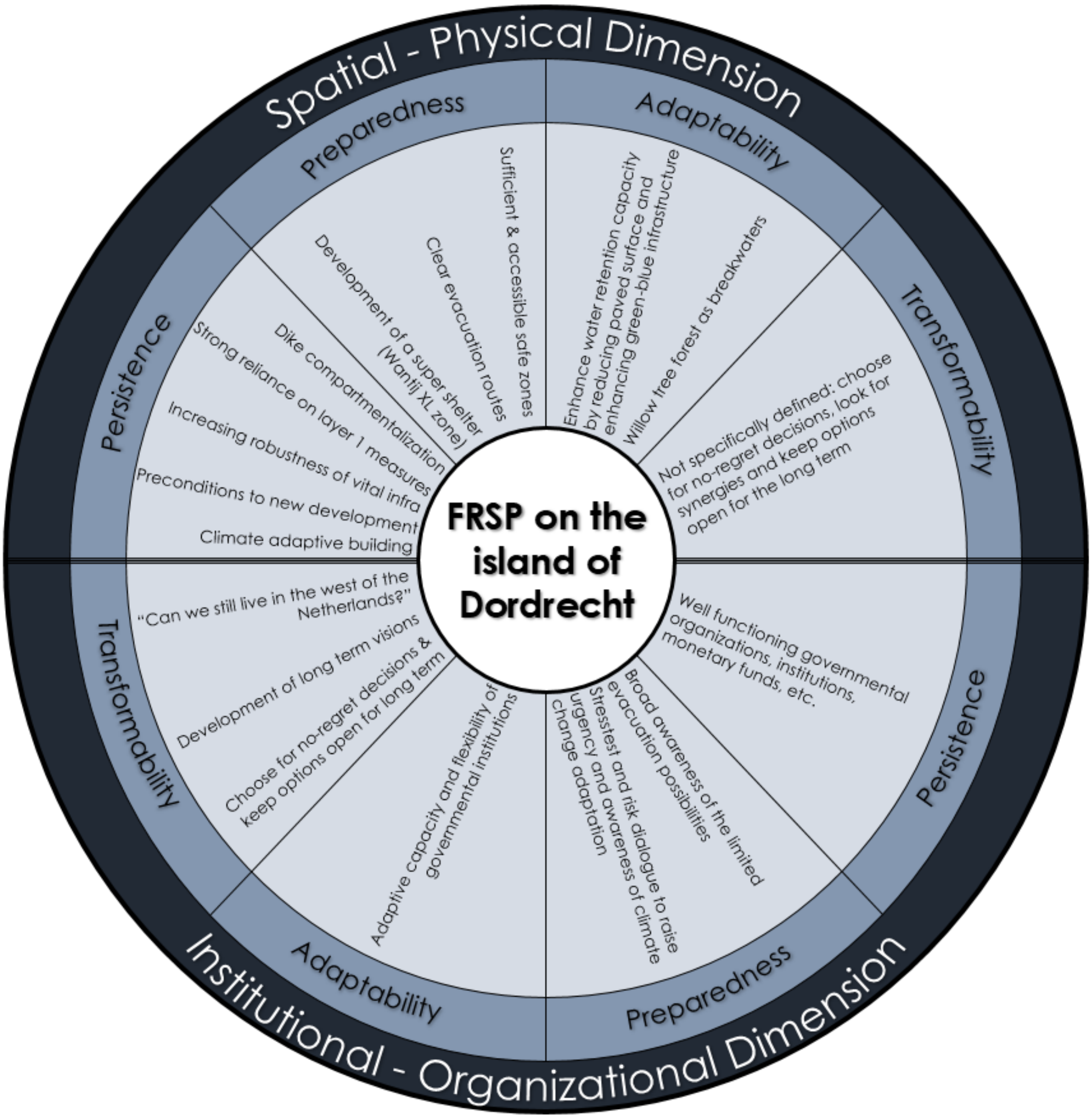

Figure 17: The Flood Resilient Spatial Planning Indicator (FRSPI) model of the island of Dordrecht (source: Author, 2019).

Table 2: Explanation of the FRSPI model of the island of Dordrecht (figure 17) (source: Author, 2019).

Category	*Compo-nent*	*Targeting issues*	*Description*	*Source*
Spatial – Physical Dimension	Persistence	Climate adaptive building	Climate adaptive building or construction is a broad term, but it mostly relates to the incorporation of climate adaptation in the lay-out of the built environment. This can be done in various ways: from the elevation of valuables (e.g. utility services, critical infrastructure, data centres) and vulnerabilities (e.g. schools, hospitals, elderly homes), to the flood-proofing of buildings with water robust base walls or mobile baseboards on doors and windows.	Interview 1 (2019) Interview 2 (2019) Interview 4 (2019)
		Preconditions to new development	Currently, the municipality of Dordrecht is working on a set of preconditions for all new urban development with regard to their functioning against water disturbance, water safety, droughts and heat stress. The province of South-Holland worked on these preconditions with their covenant 'Climate Adaptive Building'. These preconditions are moderately concrete performance requirements of all new development within the municipality. Examples of such are the obligation that every privately owned property should have the capacity to retain at least twenty millimetres of water, that a certain percentage of land-use of a specific area has to be green, or more concrete building regulations to new real estate projects: the construction of water-retaining baseboards in front of doors, placing stone tiles instead of wooden laminate flooring on the ground floor of buildings, or the obligation to have skylight windows to assure people are not trapped in their attics during a flood.	Interview 2 (2019) Interview 3 (2019) Interview 8 (2019)
		Increasing robustness of vital infrastructure	In times of water disturbance or floods, it is essential (also to allow evacuations or incoming aid) to have functioning critical infrastructure such as available drinking water, working electricity, and data connections. Increasing the robustness of vital infrastructure is and should be a prime focus of flood resilient spatial planning.	Interview 2 (2019) Interview 4 (2019)
		Strong reliance on layer 1 measures	Despite efforts made in the second and third layer of the MLS concept, the first layer remains the most important for the island of Dordrecht. Reducing flood probability remains the best way to reduce damages and consequences, also due to the system's characteristics of Dordrecht: floods hazard is big due to its maximum depth. This also forms a large barrier to both second and third layer measures.	Interview 2 (2019) Interview 3 (2019) Interview 4 (2019) Interview 5 (2019)
		Dike compartmentalization	The compartmentalization of the primary dike ring surrounding the island of Dordrecht divides the island into smaller compartments, and can act as a buffer in times of a breach of the primary dike ring. Nevertheless, this compartmentalization strategy is not always a solution, as for some regions its effects can be negative.	Deltaprogramma (2013) Interview 5 (2019) Interview 6 (2019)
	Preparedness	Development of a super shelter (Wantij Zone)	The Wantij Zone is a major blue-green corridor in which the municipality is planning for a large scale urban transformation over the upcoming years. Paradoxically enough this area is largely located outside of the embanked areas of the island. Nevertheless, due to its high elevation, it has a relatively low flood risk. An ambition of the municipality is therefore to turn this area into a super shelter; 'Noah's Ark'; a safe zone to evacuate to.	Interreg[4] (2018) Interview 2 (2019)
		Clear evacuation routes	An important aspect – and a hybrid mixture between the second and third layer of the MLS approach – is the spatial allocation and consideration of clear evacuation routes.	Interview 5 (2019)
		Sufficient & accessible safe zones	As another hybrid mixture between layer 2 and layer 3 measures next to the development of clear evacuation routes, the municipality of Dordrecht is focussing on establishing sufficient and accessible safe zones at the end of these routes, where people can evacuate to within the borders of the island of Dordrecht. Due to its spatial characteristics as an island, the system is vulnerable, and evacuation option outside the island might be limited.	Interview 2 (2019) Interview 4 (2019) Interview 5 (2019)

	Adaptability	Enhance water retention capacity by reducing paved surface and enhancing green-blue infrastructure	Preconditions to new urban development set in the covenant 'Climate Adaptive Building', or the Ecoshape consortium, enhanced water retention capacity of Dordrecht by reducing hardened, paved surface and enhancing green-blue infrastructure. This is done both on public grounds (e.g. where modification to the tiling of parking lots or the development of water retaining parks and wadi's enhance rainfall infiltration), and on public grounds (e.g. the greening of gardens and roofs).	Interview 1 (2019) Interview 8 (2019) Gersonius et al. (2015) Living Lab RA (2019)
		Willow tree forest as breakwaters	The plantation of a willow tree forest in the foreland of Dordrecht can act as breakwater and reduce wave intensity while simultaneously act as green park with recreational quality.	Gersonius et al. (2015)
	Transfor-mability	Choose for no-regret decisions, look for synergies and keep options open for the long term	Strategies or measures in the spatial-physical domain that can enhance the transformability of the island of Dordrecht are not specifically or concretely defined. Nevertheless, here it is important to choose for no-regret strategies and measures that keep options open for the long-term and can be tied to other developments so synergies are reached.	Interview 1 (2019) Interview 4 (2019) Gersonius et al. (2015)

Institutional – Organizational Dimension	Persistence	Well-functioning governmental organizations, institutions, monetary funds, etc.	The most important persistence enhancing factor regarding flood resilient spatial planning in the institutional and organizational domain are well functioning governmental organizations and institutions that collaborate well with each other on multiple levels and across multiple sectors. Clear financial arrangements need to be present, including a structured division of responsibilities. Although intentions are good, there is room for progression regarding this field in the case of the island of Dordrecht.	Interview 1 (2019) Interview 2 (2019) Interview 5 (2019) Interview 8 (2015)
	Preparedness	Broad awareness of the limited evacuation possibilities	There is on an administrative level a broad awareness that Dordrecht is located on an island. In the case of water extremes it therefore has to be largely self-reliant, because the evacuation possibilities are limited: there are only three bridges and all the surrounding dike rings will also be in serious threat in times of a potential flood	Interview 4 (2019) Interview 5 (2019) GroenBlauw (2019)
		Stresstest and risk dialogue to raise urgency and awareness of climate change adaptation	The stresstest and the risk dialogue are important ambitions and means to work towards a water robust and climate proof region, following the national Delta Plan on Spatial Adaptation (2018). The stresstest and risk dialogue contribute to the establishment of a better risk perception, and therefore generate more urgency, awareness and preparedness.	Deltaplan Ruimtelijke Adaptatie (2018)
	Adaptability	Adaptive capacity and flexibility of governmental institutions	The degree of flexibility (therefore the adaptive capacity or adaptability) of the institutional-organizational domain are difficult to translate into concrete targeting issues and indicators. Nevertheless, it describes how easily and/or quickly both public and private institutions are able to alter in the face of uncertainty and changes. Assessing the adaptive capacity of the institutional domain of the island of Dordrecht is therefore difficult if not impossible: how can one assess the adaptive capacity of a system towards events that have not yet occurred? Only the future can tell.	Interview 8 (2019)
	Transformability	Choose for no-regret decisions & keep options open for long term	Although not specifically defined in the plans and strategies of the island of Dordrecht, to enhance the transformability of the region on the long term, it is important to choose for so called no-regret measures and strategies that will leave options open as long as possible for the long-term.	Interview 1 (2019) Interview 4 (2019)
		Development of long term visions	The development of long term visions is important to define the course of direction of a region in its climate change adaptation strategy.	Interview 5 (2019)
		"Can we still live in the West of the Netherlands?"	Instead of focussing on flood probability reduction and consequence reduction, a system like the island of Dordrecht should ask the question is it is still possible to live in the West of the Netherlands.	Interview 1 (2019)

Table 2: Explanation of the FRSPI model of the island of Dordrecht (source: Author, 2019).

5.2.3 | Barriers for flood resilient spatial planning

Like the targeting issues, the barriers for flood resilient spatial planning mentioned by the interviewees can roughly be divided under the institutional-organizational dimension, and the spatial-physical dimension.

A persistent barrier to flood resilient spatial planning in Dordrecht in the institutional-organizational dimension is finance. “The second and third layer of the MLS approach structurally struggle with a lack of money. For primary flood defense there is the national Delta Fund, but it always remains fuzzy who is responsible to pay for second and third layer measures” (Interview 2, 2019). Flood resilient spatial planning measures are additional to the defense provided to us by the first layer, and therefore it comes with additional investments that not everybody is willing to make. Especially, because these investments have to be made on the short term, while the return is only visible on the long term (Interview 8, 2019). “So put simply, we need money and manpower in the preparation and implementation phase. There are no rules to sort this out, and therefore no money” (Interview 1, 2019). And even when there would have been money, it still remains debatable what the most effective and efficient purpose of this money is. “When the chances of a flood are so small, then you are not going to flood-proof each and every single building in Dordrecht. These benefits do not outweigh the costs” (Interview 2, 2019).

A second reoccurring barrier in the institutional-organizational dimension mentioned by the interviews were obstacles in the collaboration between the important stakeholders in flood risk management. “Every actor and stakeholder pursues his own interests, and climate change adaptation is for a lot of them not a number one urgency” (Interview 8, 2019). “How can you couple the interests of water boards, the real estate market, governmental bodies, and drinking water suppliers in such a way that everybody pursues climate change adaptation? It requires an extensive reorganization of the entire decision making process in which sectoral walls need to be breached” (Interview 1, 2019). The scarce space in Dordrecht is used by so many different actors for so many different functions. “How do you bring all of that together? Often we are still standing with our backs towards each other” (Interview 1, 2019). The integration between different sectors is therefore much needed, but on the other hand is can also be obstructing for climate change adaptation, as it elongates the decision making process (Interview 8, 2019). “Sometimes it is better to work in a sectoral manner. Prepare as sectoral as possible, but then integrate and collaborate for a while to find common grounds as you think through the changes that require a proactive stance” (Interview 1, 2019).

A main obstacle for the development of the Wantij Zone is the offset and unfair risk perception. “People have the misconception that the unembanked areas are unsafe, and therefore do not want to live in or evacuate to those places” (Interview 2, 2019). “It is not a straight forward matter of money. Climate change adaptation is also really a matter of perception and awareness in the mind-set of people. We have a long way to go regarding the latter” (Interview 1, 2019).

With regard to the spatial-physical barriers to flood resilient spatial planning, the maximum flood depth was mentioned by the interviewees. “The flood risk in Dordrecht originates almost fully from the primary system. This has consequences on flood probability, but also on potential consequences: they are severe” (Interview 5, 2019). For most parts of the island of Dordrecht, the maximum flood depth exceeds two meters. “If this happens, than looking at this second layer is pointless. Then you just need to make sure that there are good evacuation plans” (Interview 2, 2019). Further spatial-physical barriers mentioned were the lack of space in the urban environment of Dordrecht (Interview 1, 2019). “To build climate robust, we simple need space, and space is scarce” (Interview 8, 2019). The rigidity of the pre-existing built environment present in this urban environment reduces the possibilities to radically change the city of Dordrecht (Interview 2, 2019), revealing signs of system path dependency and lock-in.

5.2.4 | Solutions and opportunities

According to the second interviewee, big steps are taken to solve the financial barrier for flood resilient spatial planning, as by 2020 a new Delta Law should make it possible to invest in second and third layer measures with money from the national Delta Fund (Interview 2, 2019). Furthermore it is important not only to work for climate change adaptation, but to address planning integrally with other ambitions such as the striving for sustainability (Interview 2, 2019), or other urban developments in Dordrecht. This increases the available budget, and may reduce the financial barrier. It is about making smart combinations between water, nature, biodiversity, infrastructure, etc.: an integral approach (Interview 8, 2019). Collaborating with an international architecture biennial, Dordrecht is trying to breach the barrier of the lack of awareness and preparedness. Goal of this collaboration is the development of an attractive long term vision which emphasises the integral development of Dordrecht benefitting not only water resilience, but also aspects as social cohesion and the general quality of the living environment. Combined, it has to lead to a broadly supported long term vision (Interview 2, 2019). Communication and framing is very important in this process. Policy proposals that propose green-blue infrastructure "to contribute to an attractive and healthy neighbourhood" have a much higher success rate compared to policy proposals that propose green-blue infrastructure "to mitigate the consequence of a cloudburst that happens once in a century" (Interview 8, 2019). "Present and deliver your visions on a positive and attractive manner" (Interview 2, 2019; Interview 8, 2017). Framing and reframing is therefore an important instrument that can breach some important institutional-organizational barriers. "For resilience you need self-reliance, and for this self-reliance, social-cohesion is very important. We should see flood resilient spatial planning as a leverage for sustainable regional development" (Interview 2, 2019).

An opportunity for flood resilient spatial adaptation is that a lot of related measures also promote and foster a healthy environment. Green-blue infrastructure is an example of a water infiltration enhancing, retention and storage measure, but comes with a lot of co-benefits, such as improvements in health and general wellbeing of the surrounding environment (Interview 1, 2019). "A wadi is a green retention area to accommodate peak precipitation, but most of the time it just functions as a public green space, which the surrounding urban dwellers can use" (Interview 8, 2019). Whereas measures in the first MLS layer are generally rigid, infrastructural measures with a singular function, an opportunity and advantage of second layer measures is that it offers added value for neighbourhoods (Interview 8, 2019). At the same time, flood resilient spatial planning offers the opportunity to make better use of those areas that would otherwise have a large unused potential. "A lesson we can learn from Dordrecht is to perceive unembanked outer-dike areas much more as an opportunity, that offers potential to be developed in a sustainable way" (Interview 2, 2019).

5.3 | Empirical analysis of the IJssel-Vecht Delta

The third and final section of the Results chapter analyses the three expert-interviews directly related to the IJssel-Vecht Delta region: interviews 6, 7, and 9. Additionally, IJssel-Vecht Delta-related extracts from interviews 3, 4 and 5 have been used if possible and relevant.

5.3.1 | Resilience and Multi-Layer Safety in the IJssel-Vecht Delta

The term 'resilience' was directly related to climate change adaptation by the interviewees of the second case in this thesis. It was translated with the Dutch word *"veerkracht*", not only for water related issues, but also for droughts and heat stress (Interview 6, 2019). Furthermore, the term 'water robustness' was used to describe resilience. "The IJssel-Vecht Delta is located at the end of two rivers, which discharge a considerable amount of water. At the same time we need to deal with the influence of the IJsselmeer in the west. Everything comes together in this delta, and that results in several problems, especially with a changing climate. Resilience is about how we defend us against this. How do you prevent severe problems and disruptions from happening?" (Interview 9, 2019).

The ideal target point on the horizon is to transform into a system that is capable of retaining, storing and reusing water in dry periods (Interview 6, 2019); a system that does not disturb its natural system and processes; a system that does not hamper infiltration capacity; a system that carefully considers its flood prone areas. Spatial planning can and should fulfil a crucial role in this, as it is able to enhance the water resilience of the total system (Interview 7, 2019). Persistence and water robustness are components of resilience that – also in the IJssel-Vecht Delta – fulfil an important role. Not only through the protection that robust first layer dikes provides the region, but also through persistent second MLS layer measures. Good examples can be found in the relatively new neighbourhood in the northwest of the city of Zwolle, called Stadshagen. Various districts of this neighbourhood are built on elevated grounds: almost on dwelling mounds. Throughout Zwolle, more neighbourhoods can be found that have been developed at delta sea level. The same goes for several farms on Kampereiland, that have been built on dwelling mounds (Interview 9, 2019). Between Stadshagen and the N331 motorway, a one meter high water robust noise barrier has been constructed on top of a clay layer able to withstand a flood (IJssel-Vechtdelta, 2018). This barrier was primarily meant to block noise, but making use of synergies, it has now also be designed as a compartment dike that can absorb the first wave of water after a dike breach of the river IJssel (Interview 6, 2019; Interview 7, 2019; Interview 9, 2019). The persistence of the region is fostered by regional collaboration between governments, but also collaboration with entrepreneurs, educational institutes and citizens (Interview 7, 2019). Furthermore, the region is involved in multiple international projects and partnerships, such as Interreg CATCH, and LIVE (IJssel-Vechtdelta, 2015).

Water robustness and -resilience should therefore be considered a priori to new development and construction. In the IJssel-Vecht Delta this awareness is certainly growing over recent years. The core stakeholders (municipalities, water board, province and Safety Region) agreed on the obliged incorporation of the consideration of such water values into their plans by 2020. Even though the Program IJssel-Vecht Delta is relatively young, it already had a considerable impact (Interview 9, 2019), illustrated by numerous examples and projects throughout the IJssel-Vecht Delta. Efforts towards improving awareness and preparedness formed a crucial part of the Program. The Province of Overijssel provided information, campaigned and educated to improve this water awareness. Especially also for young children, to get them acquainted with water and climatic issues early on in their development (Interview 9, 2019). Furthermore, in Zwolle the project 'SensHagen' is currently running, in which inhabitants have measuring instruments in their own house and garden from which they receive updates about topics such as groundwater- and precipitation levels: again, to foster water awareness (Interview 9, 2019; Gemeente Zwolle, 2019). Another example comes from the Kampereilanden, an area on lower grounds, located northwest of the city of Kampen. Inhabitants of this area are warned via a text message on their phone in times of water threat (Interview 6; 2019). Nevertheless, the best examples where there has been worked on water awareness and preparedness comes from the city of Kampen itself. In Kampen, a substantial part of the primary water defence system of the inner city centre relies on a mobile dike (Interview 5, 2019) that is built up by a team of volunteers: the High Water Brigade. Each year this team practices, and within a few hours the centre of Kampen can be made water proof (Interview 9, 2019). A preparedness enhancing measure in the spatial-physical dimension can be found in the efforts of the Safety Region of the IJssel-Vecht Delta, which is actively managing the realization of sufficient and accessible highly located safe zones where people can evacuate to in the case of a flood. This, in combination with a flexible evacuation strategy ensures multiple action perspectives for every region of the IJssel-Vecht Delta and fosters the effectiveness and efficiency of crisis management (IJssel-Vechtdelta, 2015; Interview 6, 2019; Interview 7, 2019).

Spatial-physical measures that enhance the third component of resilience – adaptability – can also be found throughout the IJssel-Vecht Delta. Since 2014 governments have been working on a Spatial Development Plan for the Kampereilanden, in which there is a pursuit to tie current water challenges to the qualities of the landscape (Gemeente Kampen, 2017). In this region a multitude of measures are in place, under construction or planned for. For example there have been adjustments to a current dike, which allows overflow in times of extreme high water levels while ensuring the ruling out of a potential dike breach (Interview 7; 2019). In fact, this flexible and adaptive measure can be described as a hybrid mixture between a first- and second layer measure (Interview 9; 2019). Furthermore, there is the new real estate project 'Frankhuis', located in the northwest of the city of Zwolle, right at the banks of the Zwarte Water. In the spatial planning process, this project took future increases of water safety standards into account as the project was built on a robust, double level quay (Interview 9, 2019). Furthermore, the project tried to minimize the obstruction of natural rainwater infiltration despite the increase of hardened and paved roofs and streets (IJssel-Vechtdelta, 2018). Water infiltration enhancing, or water retention and storage capacity enhancing measures can be found in more places throughout the IJssel-Vecht Delta: wadi's that form an extra buffer to store superfluous water (Interview 9, 2019), and green-blue infrastructure networks throughout the city of Zwolle (Interview 6, 2019). Ultimately, signs of spatial-physical transformability have not been mentioned by the interviewees. In the institutional-organization dimension, only the development of long term visions (Interview 5, 2019) and choosing for no-regret strategies (Interview 4, 2019) can be mentioned here.

5.3.2 | Assessing resilience: the IJssel-Vecht Delta in the FRSPI model

The region IJssel-Vecht Delta is full of exemplar cases in which the flood risk resilience was enhanced by layer 2 strategies and measures. An elaborate overview of these projects can be found in the document of the province of Overijssel: "*IJssel-Vechtdelta: werken aan waterveiligheid en klimaatadaptatie; overzicht van projecten in dit Overijsselse deltagebied".* Next to this remark, the same remarks as given in section 5.2.2. apply to the construction of the FRSPI model and corresponding explanatory table as given below in respectively figure 18 and table 3.

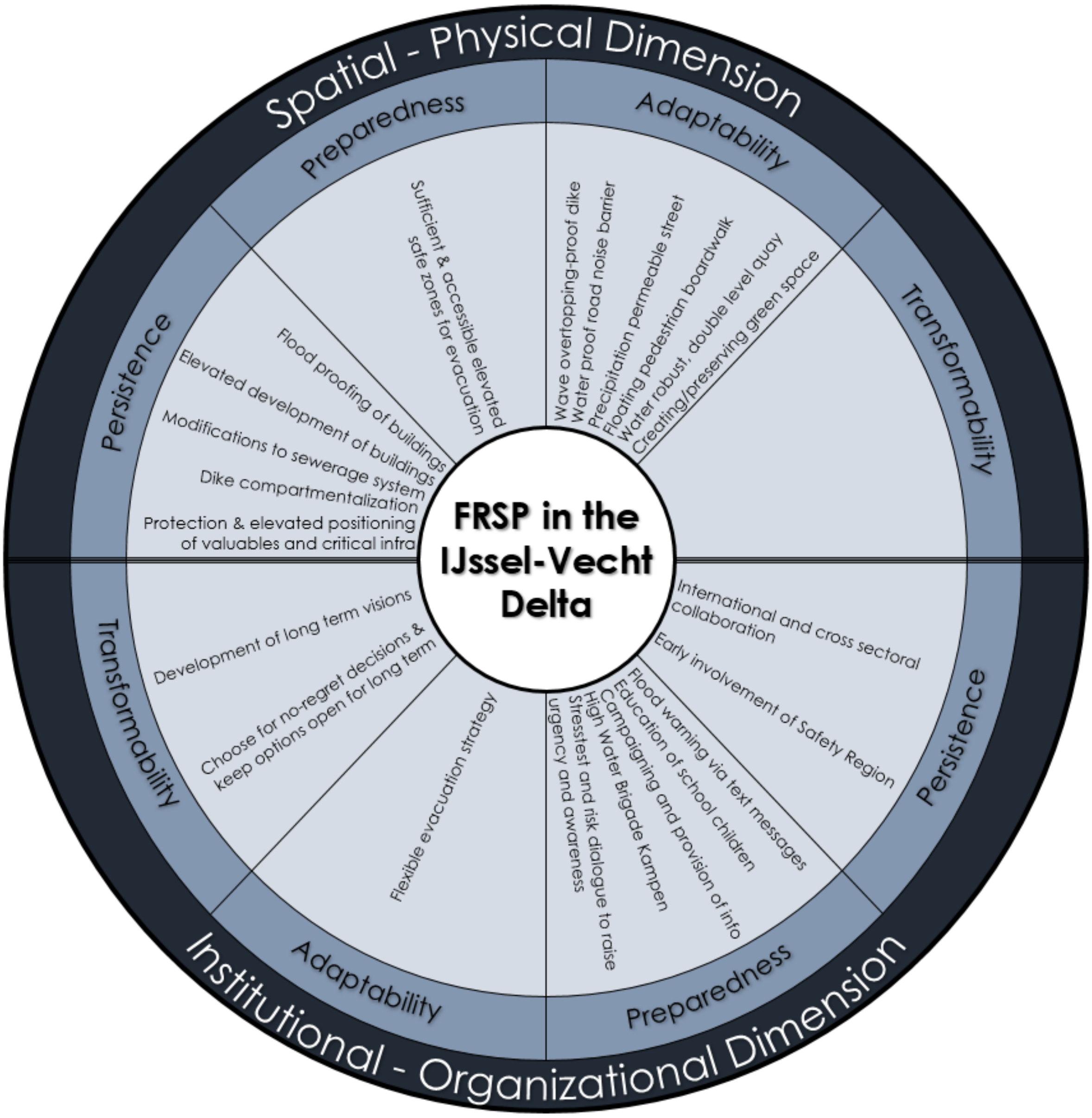

Figure 18: The Flood Resilient Spatial Planning Indicator (FRSPI) model of the IJssel-Vecht Delta (source: Author, 2019).

Table 3: Explanation of the FRSPI model of the IJssel-Vecht Delta

Category	*Compo-nents*	*Targeting issues*	*Description*	*Source*
Spatial – Physical Dimension	Persistence	Protection & elevated positioning of valuables and critical infrastructure	In e.g. the redevelopment of the Kraanbolwerk district in Zwolle, on the Rodetorenplein in the inner city centre, and the redevelopment of the business park in Hasselt, important utility services such as electricity transformers are placed high above the ground. Currently an impact analysis is done for the fresh water supply of the region via the Engelse Werk station.	IJssel-Vechtdelta (2015) IJssel-Vechtdelta (2018) Interview 1 (2019)
		Dike compartmentalization	For a restricted amount of money, a compartmentalizing dike is planned for around Genemuiden. The realization of the flood consequence reducing compartment dike will comply to further spatial developments in the upcoming years.	Interview 7 (2019) IJssel-Vechtdelta (2015)
		Modifications to the sewerage system	In the redevelopment of the business park of Hasselt, modifications have been made to the sewerage system. Non-return valves have been installed which avoid floods from the sewerage system in times of high water discharge.	IJssel-Vechtdelta (2018)
		Elevated development of buildings	Multiple districts, neighbourhoods and further newly developed real estate has been developed on top of elevated grounds (e.g. dwelling mounds). Examples of this can be found in the VINEX location in Zwolle: Stadshagen and in Kraanbolwerk. Furthermore, multiple farms and agricultural businesses have or will be developed on top of such dwelling mounds.	Interview 9 (2019) IJssel-Vechtdelta (2018)
		Flood proofing of buildings	The basement walls of the buildings of several districts of Zwolle and Kampen are part of a robust dike (e.g. Weezenlanden, the hardware store 'Hornbach', and the historic city centre of Kampen). Furthermore, arrangements in quays and banks have been made where mobile beams can almost instantly form a water robust dike.	Interview 9 (2019) IJssel-Vechtdelta (2018)
	Prepared-ness	Sufficient & accessible elevated safe zones for evacuation	The Safety Region of the IJssel-Vecht Delta is actively managing the realization of sufficient and accessible highly located safe zones where people can evacuate to in the case of a flood. This, in combination with a flexible evacuation strategy ensures multiple action perspectives for every region of the IJssel-Vecht Delta and fosters the effectiveness and efficiency of crisis management.	IJssel-Vechtdelta (2015) Interview 6 (2019) Interview 7 (2019)
	Adaptability	Wave overtopping-proof dike	A lot of the primary dikes protecting Kampereiland were until recently insufficient. With recent project they have been brought up to date to the desired safety standards. Part of these dikes have intentionally kept lower. At these places wave overtopping is allowed for; with a controlled flooding of the area as a result.	IJssel-Vechtdelta (2018) Interview 3 (2019) Interview 7 (2019)
		Water proof road noise barrier	Between the neighbourhood Stadshagen and the N331 motorway, a one meter high water robust noise barrier has been constructed on top of a clay layer able to withstand a flood. This barrier was primarily meant to block noise from the motorway, but making use of synergies, it has now also be designed as a compartment dike that can absorb the first wave of water after a dike breach of the river IJssel.	IJssel-Vechtdelta (2018) Interview 6 (2019) Interview 7 (2019) Interview 9 (2019)
		Precipitation permeable street	At several locations in Zwolle (e.g. Frankhuis, Nieuwe Markt, Hornbach, etc.), slight modifications to street tiling have enhanced the precipitation infiltration capacity. Rainfall can more easily flow away into the soil, resulting in fewer water problems in times of extreme rainfall.	IJssel-Vechtdelta (2018)

		Floating pedestrian boardwalk	At several locations in the IJssel-Vecht Delta (e.g. redevelopment Pannekoekendijk/Katerdijk, water front Hasselt), a floating pedestrian boardwalk has been developed, directly adapting to fluctuations in water levels.	IJssel-Vechtdelta (2018)
		Water robust, double level quay	The real estate development project Frankhuis in Zwolle has been realized on a water robust, double level quay, as this project took future increases of water safety standards into account.	Interview 9 (2019) IJssel-Vechtdelta (2018)
		Creating/preserving green space	Throughout the IJssel-Vecht Delta green space has been preserved and created where possible (e.g. redevelopment of the Pannekoekendijk/Katerdijk, the Weezenlanden, the Seringenstraat, Hornbach, Hasselt, etc.), due to its important function in climate change adaptation strategies: it reduces heat stress, while it also intercepts, retains and stores precipitation.	IJssel-Vechtdelta (2018) Interview 6 (2019)
	Transformability	-	-	-

Institutional – Organizational Dimension	Persistence	International and cross sectoral collaboration	Due to the complex challenges in the IJssel-Vecht Delta, collaboration is key. There is regional collaboration between governments, but also collaboration with entrepreneurs, educational institutes and citizens. Furthermore, the region is involved in multiple international projects and partnerships, such as Interreg CATCH, and LIVE.	Interview 7 (2019) Interview 9 (2019) IJssel-Vechtdelta (2015)
		Early involvement of the Safety Region	To organise the crisis management task of the Safety Region more effectively, this institution is involved early in the decision making process, as they have an important advisory role in the development of spatial and policy visions. This early involvement of the Safety Region can contribute to a smarter spatial planning and configuration of spatial development and maximise evacuation options.	IJssel-Vechtdelta (2015) Interview 9 (2019)
	Preparedness	Flood warning via text message	As the inhabitants of Kampereiland live in an area prone to flooding, inhabitants are warned via a text message on their phones in times of a potential water threat.	Interview 6 (2019)
		Education of school children	In the establishing of a fair risk perception, and to generate awareness and preparedness, education has a key role. The IJssel-Vecht Delta region wants children to get acquainted with water and climatic issues early on in their development. Therefore it develops and organises educational material and activities jointly with schools in the region.	IJssel-Vechtdelta (2015) Interview 9 (2019)
		Campaigning and provision of info	A prime means of the IJssel-Vecht Delta region in generating social awareness and preparedness is by campaigning (e.g. the national campaign “Ons Water”) and the provision of sufficient and accessible information (e.g. the mobile phone app “Huisje Boompje Beter”, online websites, digital media, newsletters, symposia, and excursions).	IJssel-Vechtdelta (2015) Interview 9 (2019)
		High Water Brigade Kampen	A substantial part of the primary water defence system of the inner city centre of Kampen relies on a mobile dike that is built up by a team of volunteers: the High Water Brigade. Each year this team practices, and within a few hours the centre of Kampen can be made water proof.	Interview 6 (2019) Interview 7 (2019) Interview 9 (2019)

		Stresstest and risk dialogue to raise urgency and awareness	The stresstest and the risk dialogue are important instruments to work towards a water robust and climate proof region, following the national Delta Plan on Spatial Adaptation. The stresstest and risk dialogue contribute to the establishment of a better risk perception, and therefore generates more urgency, awareness and preparedness.	Deltaplan Ruimtelijke Adaptatie (2018)
	Adaptability	Flexible evacuation strategy	The Safety Region of the IJssel-Vecht Delta has developed a flexible evacuation strategy for the entire IJssel-Vecht Delta. Per region, it carefully considers what the best evacuation options are: voluntarily stay, voluntarily evacuate, obliged stay or obliged evacuate. Due to the early on involvement of the Safety Region in the spatial decision making process, the flexible evacuation strategy will become more robust – while remaining flexible – over the upcoming years.	IJssel-Vechtdelta (2015)
	Transformability	Choose for no-regret decisions & keep options open for the long-term	Although not specifically defined in the plans and strategies of the IJssel-Vecht Delta, to enhance the transformability of the region on the long term, it is important to choose for so called no-regret measures and strategies that will leave options open as long as possible for the long-term.	Interview 4 (2019)
		Development of long term visions	The development of long term visions is important to define the course of direction of a region in its climate change adaptation strategy. Starting point of the water safety and climate proof strategy of the IJssel-Vecht Delta is the question how to ensure a safe region to work and live in the year 2050 and 2100, despite its water challenges.	IJssel-Vechtdelta (2015) Interview 5 (2019)

Table 3: Explanation of the FRSPI model of the IJssel-Vecht Delta (source: Author, 2019).

5.3.3 | Barriers to flood resilient spatial planning

Despite the substantial uptake of flood resilient spatial planning which had led to numerous examples of second layer measures, the interviewees which are directly involved in the IJssel-Vecht Delta region also identified numerous persistent barriers obstructing a further uptake.

"Two important institutional-organizational barriers are financing and awareness" (Interview 9, 2019). Flood resilient spatial planning simply costs money. It is difficult to gather this money at the time when awareness is low, and the money is spend on long term purposes, for events that have a low probability of happening at all (Interview 9, 2019). "In a new, blank polder such second layer measures might have a lot of opportunities, but in an already existing and built-up environment, threading flood resilient spatial is unbelievably costly, which makes first layer dike reinforcements much more efficient (Interview 7, 2019). Not only the actual construction of the measures is expensive, but also the maintenance. "That water blocking noise barrier is for example a nice idea, but for the upcoming years we need to carefully maintain it following the strong standards compartmenting dikes have to adhere to" (Interview 7, 2019). Such compartment dikes are already contentious: "You are creating smaller compartments, which in fact increases the flood risk of some areas. You are turning some compartments into bathtubs which flood at a rapid speed, and from where it is more difficult to get the water out again" (Interview 6, 2019).

Much efforts have been undertaken to increase water awareness. The central means to foster this is by starting a dialogue with the region, emphasising the added value that the second layer can offer. However, this proved to be a difficult undertaking (Interview 9, 2019). Nevertheless, the interviewees admitted it to be absolutely crucial, as awareness is needed to generate willingness and support for plans both on administrative level, and on the public level. "The latter fulfils defines the success of climate change adaptation strategies, because the chain is as strong as the weakest link. Only a small percentage of the total land surface of the IJssel-Vecht Delta is publicly owned. The largest share is in the hands of private enterprises, companies and house owners. One way or another, this group has to be involved in climate change adaptation for establishing a successful approach" (Interview 9, 2019).

With regards to responsibility ambiguity, there were mutual differences in the answers and perceptions of the three interviewees. One expert interview from the Province of Overijssel elucidated the transparent and well organised governance process behind the approach of the IJssel-Vecht Delta: "Governance has been one of the strong assets of the programme. Through close collaboration, we have been able to achieve objectives that individual organizations and administrations could have never done alone. There was a steering group consisting of representatives of all important stakeholders, that met on a frequent basis to discuss all contentious points of attention. Only rarely large problems arose here" (Interview 9, 2019). On the other hand, the two other interviewees from the water board Drents-Overijsselse Delta most certainly perceived some governance issues during the process: "This second remains a responsibility of the municipalities. We merely have an advisory role" (Interview 7, 2019). "We are still investigating what our role as a water board should or could be in this process" (Interview 6, 2019). There is not only uncertainty on the administrative level and financial level, but also technologically many measures and strategies are still under debate (Interview 6, 2019). A final institutional barrier mentioned by the interviewees is that flood resilient spatial planning is sometimes obstructed by bureaucratic rules. "Elevated environments would be a persistence enhancing measure, but in the IJssel-Vecht Delta, building regulations prohibit building higher than nine meters" (Interview 6, 2019).

A large spatial or physical barrier to second MLS layer mentioned by the interviewees is that it has to be implemented in an already existing built environment (Interview 7, 2019). In relation to this, a lack of space forms another barrier. "In Zwolle, we are dealing with an urban environment, not every measure can be fit in here" (Interview 9, 2019). Furthermore, aesthetics can form a barrier to flood risk management measures: "We could build a high dike around the entire centre of Kampen, but this would ruin the entire city front" (Interview 9, 2019). A final spatial-physical barrier was mentioned by the seventh interviewee: "measures to alleviate some water disturbance from precipitation are easy, but if we are talking about a polder in which the water during a flood reaches four metres, then your options in this second layer are limited. From my perspective, second layer measures could be effective up to flood depths of about a metre. If floods are deeper than this… Well, do not even try then." (Interview 7, 2019).

5.3.4 | Solutions and opportunities

Also in the IJssel-Vecht Delta there are barriers to the second MLS layer. However, also solutions can be found to breach those barriers, and hence there are opportunities for flood resilient spatial planning. These opportunities are partially the effect of the natural characteristics of the system of the IJssel-Vecht Delta. “It is a larger region with a more varied flood risk and probability. Generally, as the main flood risk originates from the regional system, flood probability is higher but the average flood depths are more shallow, which makes the second MLS layer by definition more promising. Because when every hundred year there is a twenty centimetre flood, then pretty soon flood resilient spatial planning becomes economically viable” (Interview 5, 2019). Other interviewees agree with this point: “When it concerns floods from the regional system, there are enough opportunities for this second layer” (Interview 6, 2019).

Where (the lack of) awareness and preparedness was described by multiple interviewees as a barrier, they also see it as the main solution to breach these barriers. “Policy makers should see the urgency of the matter, to stimulate awareness and preparedness, because that remains to be a constringent factor. Illustrating the potential of added value to regions and neighbourhoods can stimulate investments in second layer measures. This does not always have to come from the collective: also individual should be more proactive.” (Interview 9, 2019). This added value is a large opportunity that flood resilient spatial planning can offer. “Capturing and retaining water in green space enhances storage capacity of water, but it also revitalizes the living environment and quality of a neighbourhood” (Interview 7, 2019). Another example of the added value became apparent in Kampereilanden. “This used to be a beautiful polder area, but over the years the layout of the area cluttered a bit. In the Program IJssel-Vecht Delta, we tried to give the area a bit of its former grandeur back, by means of aesthetical climate change adaptation measures” (Interview 9, 2019). This added value alleviates the general cost-benefit imbalance slightly. Linking climate change adaptation measures to other developments in the region, could alleviate this imbalance further (Interview 9, 2019).

With regard to the barrier of collaboration and responsibility ambiguity, horizontal and vertical integration could be seen as a solution: “apart from institutions like the water boards, provinces and municipalities, also real estate developers and architects should incorporate flood risk much more in developing neighbourhoods” (Interview 7, 2019).

Solutions to the spatial-physical barriers appeared to be more troublesome. “The main opportunities of flood resilient spatial planning lie with new developments, or if we develop a lot in a low lying part of the Delta. In principle, old and pre-existing built environment is already thoroughly protected by the dikes and other primary flood defense infrastructure” (Interview 6, 2019). This seems to be a ‘barrier to the solution of the barriers’: “That is the fundamental problem that I have with the terminology of Multi-Layer Safety. It provides water safety from three sides: the primary dikes, the spatial planning, and crisis management in the case of an emergency. In fact, it is like wearing three jackets on top of each other…” (Interview 7, 2019).

6 | Discussion

This chapter consists of two parts. The first part focusses on the observed presence of flood resilient spatial planning. Section 6.1 discusses the confrontation between the two FRSPI models. Section 6.2 subsequently gives recommendations derived from this discussion. The second part focusses on the absence of flood resilient spatial planning: section 6.3 elaborates on the observed barriers to flood resilient spatial planning. Subsequently recommendations regarding this matter are given in section 6.4.

6.1 | A confrontation between the two cases

After establishing the FRSPI models of the island of Dordrecht and the IJssel-Vecht Delta in chapter 5, comparing similarities and differences between the two could bring us a step further towards developing concrete indicators of resilience. When comparing the targeting issues as mentioned in figure 17 and table 2 with the targeting issues of figure 18 and table 3, it can be noticed that there is in fact much similarity in the strategies and measures of both cases. Figure 19 and table 4 below therefore illustrate the pursuit of the summarizing and capturing of corresponding targeting issues of both cases under broader encompassing categories.

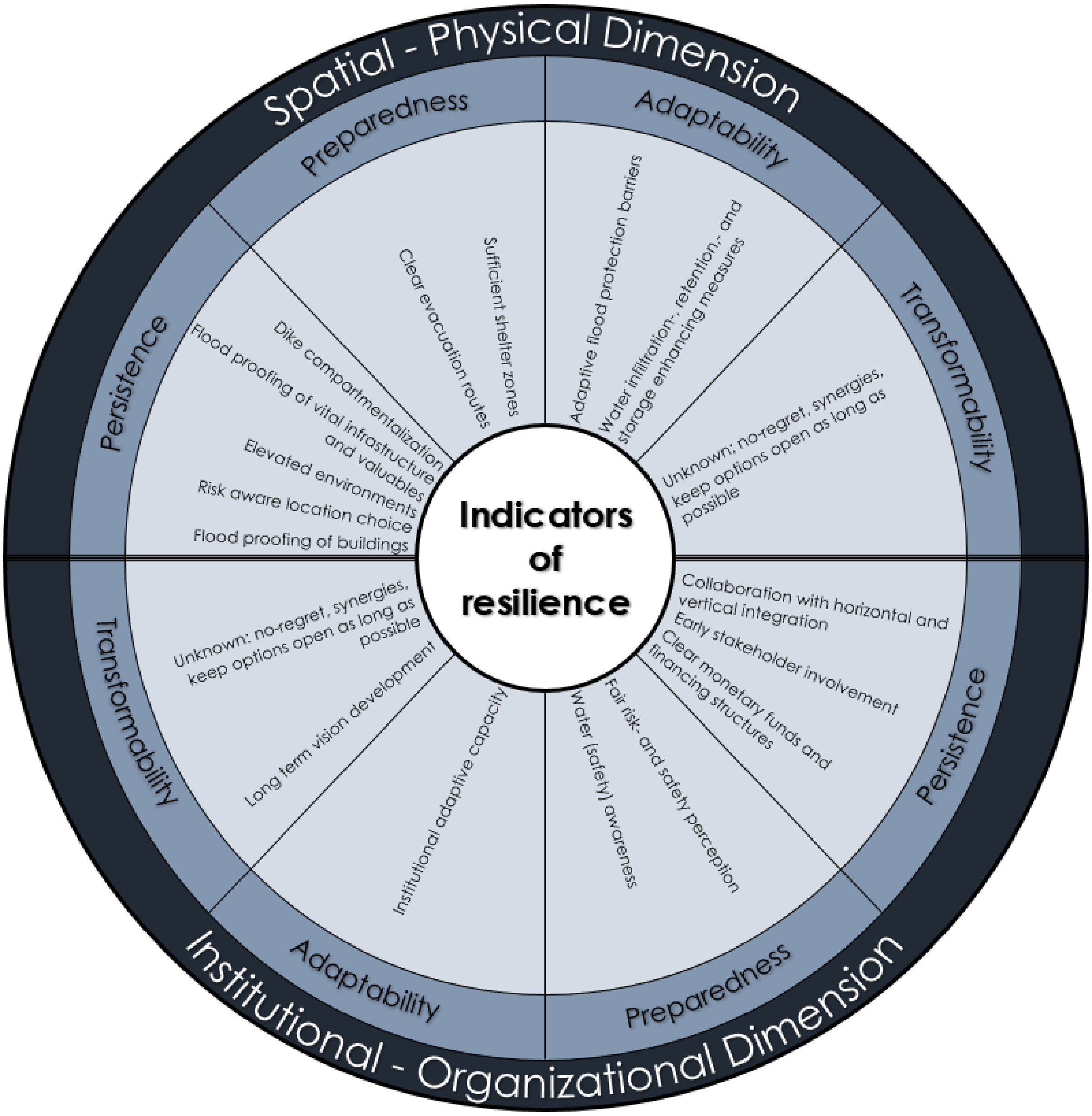

Figure 19: The Flood Resilient Spatial Planning Indicator (FRSPI) model confronting both cases (source: Author, 2019).

Table 4: Explanation of the FRSPI model confronting both cases (source: Author, 2019).

Dimension	*Resilience component*	*Indicator*	*Explanation*
Spatial – Physical Dimension	Persistence	Dike compartmentalization	The compartmentalization of dike rings behind the primary flood protection measures can be seen as a persistence enhancing indicator of resilience. Dike compartmentalization provides flood consequence reduction as only (a) compartment(s) floods, instead of the entire dike ring. Nevertheless, compartmentalization is not always a solution: for certain compartments, flood risk will actually increase after dividing a total area up into smaller sections.
		Risk aware location choice	A well-considered flood risk aware location choice of activities and land-use is a persistence enhancing indicator of resilience as it excludes vulnerabilities from flood prone areas, therefore reducing the consequences of potential floods and water disturbance.
		Elevated environments	Elevated environments enhance persistence as it literally increases the buffer between land and water in times of water disturbances and floods, therefore enhancing the power to withstand floods. Concrete targeting issues and examples of elevated environments is the construction and living on dwelling mounds, or excluding vulnerabilities to be located on ground floors.
		Flood proofing of vital infrastructure and valuables	Flood proofing of vital infrastructure and valuables is a spatial-physical persistence enhancing indicator of resilience as it increases the power to withstand water disturbance and floods of important objects, functions, and activities. Vital infrastructure is for example critical transportation routes, drinking water supply, electricity generators and providers. Hospitals, schools, data centres and elderly homes are good examples of valuables.
		Flood proofing of buildings	This description is similar as the '*flood proofing of vital infrastructure and valuables'* only this indicator regards the protection of lower ranked consequences: offices, business properties, private houses, and the like.
	Preparedness	Clear evacuation routes	Providing and safeguarding clear evacuation routes is a preparedness enhancing indicator of resilience as it regards the resilient spatial planning fundamental to adequate crisis management (layer 3). In times of a flood, a system needs to be able and have the capacity to support a large scale transfer from A to B.
		Sufficient shelter zones	Additionally to the evacuation routes itself, also the endpoints of these routes need to be provided and safeguarded. In times of severe water disturbance and floods there need to be sufficient shelter zones. There are various options for the operationalization of such shelter zones: they can be large flood-proofed buildings or grounds with a higher elevation.
	Adaptability	Adaptive flood protection barriers	Smart constructions and modifications can enhance the adaptive capacity of (primary) flood protection barriers and is therefore another indicator of resilience, inside the flood resilient spatial planning domain. Examples of adaptive flood protection barriers are the wave overtopping-proof dikes and multiple-use barriers such as a noise barrier annex compartment dike.
		Water infiltration enhancing, retention and storage measures	Precipitation permeable streets and the creation and preservation of green-blue space such as parks and green roofs are good examples of measures that foster the water infiltration, -retention, and -storage capacity of a system. As these measures make the system more flexible in times of water disturbance and floods, they can be seen as adaptability enhancing indicators of resilience.
	Transfor mability	Unknown	Concrete spatial-physical transformability enhancing indicators of resilience have not been found in the data collection and analysis of this research. What is known is that such an indicator would represent a no-regret strategy or measure, which aims for synergetic ties to other developments, and keeps options open as long as possible.

Table 4: Explanation of the FRSPI model confronting both cases (source: Author, 2019).

Dimension	*Resilience component*	*Indicator*	*Explanation*
Institutional – Organizational Dimension	Persistence	Collaboration with horizontal and vertical integration	An important persistence enhancing indicator of resilience in the institutional-organizational dimension is a comprehensive manner of collaboration between involved stakeholders. Stakeholders of flood resilient spatial planning are present on a multitude of sectors and levels. Crucial in this process is both vertical integration (the intensification of collaboration between different sectors and fields of interest, e.g. governmental authorities, the energy sector, drinking water suppliers, Safety Region, civil society, transport sector, etc.) as well as horizontal integration (the intensification of collaboration between multiple levels of government (e.g. European Union, national government, provinces, municipality, etc.). Important in this collaboration is a clear division and awareness of responsibilities under the stakeholders.
		Early stakeholder involvement	Crucial for a fruitful collaboration between stakeholders is the early involvement of those stakeholders in the decision making process. As this enhances a fair risk- and safety perception, therefore urgency, therefore awareness, and therefore preparedness to act, early stakeholder involvement increases the institutional-organizational support for flood resilient spatial planning.
		Clear monetary funds and financing structures	A third important indicator of resilience in FRSP that enhances the power to withstand floods and water disturbance in the institutional-organizational domain is the presence of clear monetary funds and financing structures to orderly divide financial responsibilities and to ensure the stable and sound economic basis that second layer measures require.
	Preparedness	Fair risk- and safety perception	Prior to preparedness to act, there needs to be a certain sense of urgency. Achieving a fair risk- and safety perception, both administrative sector and the private sector, is therefore an important indicator of resilience in the institutional-organizational domain. The stresstest is an instrument capable of exposing system' vulnerabilities, and can therefore contribute to a fairer risk- and safety perception.
		Water (safety) awareness	Prior to preparedness to act, there needs to be a certain degree of awareness. Generating awareness is therefore in close compliance to the previous indicator of resilience, and can lead to a larger institutional-organizational preparedness. There is a multitude of means to foster this awareness: the risk dialogue, the provision of information, campaigning, education, etc.
	Adaptability	Institutional adaptive capacity	This indicator describes and assesses how easily and/or quickly public and private institutions are able to alter in the face of uncertainty and continuous change. The degree of institutional and organizational flexibility (therefore the adaptive capacity or adaptability) is hard to measure, judge and value, because how can one assess the adaptive capacity of a system towards events that have not yet occurred? Therefore, concrete adaptability enhancing indicators of resilience in the institutional-organizational dimension have not been found in the data collection and analysis of this research.
	Transforma-bility	Long term vision development	Developing a long term vision of strategy helps a region to pin down the outline of its development pathway. It sets objectives and ambitions, and obliges regions to consider long term developments and transformations.
		Unknown	Apart from long term visions, other concrete transformability enhancing indicators of resilience have not been found at the basis of the data analysis. Nevertheless, to enhance the transformability of the region on the long term, it is important to choose for so called no-regret measures and strategies that will leave options open as long as possible for the long-term.

So far, only the similarities between the two cases have been mentioned. As opposed to the large degree of accordance between the two cases, there are just a few differences. Especially in terms of the lead beneficiaries behind climate change adaptation: in Dordrecht it is mainly the municipality that is working on it, assisted by other administrations and parties. In the IJssel-Vecht Delta it is much more a joint effort by the municipality, province and the water board (Interview 5, 2019; Interview 9, 2019). Another difference between the two cases is that Dordrecht has a strong focus on crisis management and the related flood resilient spatial planning associated with it (e.g. the safeguarding of evacuation routes and shelter zones) (Interview 5, 2019). The IJssel-Vecht Delta has less of a focus on one specific aspect of a strategy. Underlying reasons for this difference between the two cases are obvious, as the characteristics of both systems are very different. Dordrecht is located on an island, where evacuation possibilities are limited, maximum flood depths are very deep, and flood risk is predominantly coming directly from the primary system (Gersonius et al., 2016; Interview 4, 2019). Dordrecht therefore has to be largely self-reliant. On the other hand, the challenges of the IJssel-Vecht Delta are more varied (Interview 5, 2019), which forces the region to adopt a broader strategy. A final difference between both cases directly relates to this. As the boundaries of the system of Dordrecht are tighter than those of the IJssel-Vecht Delta, the municipality of Dordrecht has a stronger focus on stimulating measures on a smaller, individual level, such as the preconditions to new development and the ongoing dialogue on what citizens can do themselves to mitigate the effects and consequences of floods and flooding (Interview 3, 2019; Interview 8, 2019). This results in the fact that in Dordrecht, there appears to be a stronger focus on enhancing 'resilient communities' as there are simply boundaries to enhancing 'resilient areas'. In the IJssel-Vecht Delta there appears to be no predominance in focus point.

When comparing and confronting both cases, a final and important observation is that whereas there are many examples of persistence- and preparedness enhancing targeting issues and indicators of resilience (twelve, in figure 19), there are limited targeting issues and indicators that address adaptability and transformability (six, in figure 19). Especially transformability – the ability and capacity to transform from one system into another (Folke et al., 2010) – appears to be hardly considered. The interviewees only agreed that it is important to take no-regret strategies, look for synergies, and keep options open as long as possible (Interview 1, 2019; Interview 4, 2019). Other than developing long term visions (Interview 5, 2019), no concrete targeting issues or indicators were mentioned. Despite the fact that both cases do have such visions, it is debatable whether these currently suffice, as both cases do not fully consider the 'tipping point' of the system, and what can or has to be done after this point is reached. In this, both cases can find room for progression in their attempts towards water resilience. How this can be achieved exactly in both the spatial-physical dimension as well as the institutional-organizational dimension is fertile ground for future research.

6.2 | Towards indicators of resilience?

What becomes clear from all the reviewed Multi-Layer Safety measures in Dordrecht and the IJssel-Vecht Delta, is that many – if not all of them – could be categorized under multiple of the four components of resilience or under multiple of the three layers within the MLS approach: think about compartmenting dikes or wave overtopping-proof dikes (mixtures between the first and second layer) (Interview 3, 2019), the development and designation of evacuation routes and safe zones (mixtures between the second and third layer), the construction of elevated environments (an indicator of both persistence as well as preparedness) (Interview 4, 2019). It illustrates that several MLS measures are hybrid-mixtures between multiple layers or multiple components, as jointly they enforce what we call 'resilience' (Interview 5, 2019). All of this makes a closing distinction between measures, strategies, resilience components, and MLS layers a difficult undertaking, and provides a sound argument to work towards this desired 'common language' in flood risk management. The establishing of ´universal´ indicators of resilience would be a large step in the direction of such a common language, as ideally these indicators could be translated to other contexts but still remain valuable. Establishing indicators of resilience is however a precarious activity due to the intrinsic components of the term. ´Resilience´ describes the ability to change, adapt and transform in response to developments (Davoudi, 2012, p.302). Therefore, assessing resilience on the basis of indicators would convey the valuation of a system's response to future circumstances. For both dimensions in the FRSPI models this problem was especially pervasive for the 'adaptability' and 'transformability' component, which is the main explanatory factor for the lack of targeting issues and indicators found.

A valuable final step, is making the identified indicators more tangible by exploring the possibilities to make the indicators more measurable. In itself this time-consuming activity is enough basis for a whole new thesis. This aspect was beyond the central research question, and therefore scope and aim of this thesis. Below, one example per resilience component has been made. Expanding on further examples of measurable indicators of resilience is therefore directly a recommendation for future research.

6.2.1 | An indicator of persistence

A determining indicator of resilience in being persistent or robust, is the flood depth. As mentioned many times in the expert interviews, the success or failure of flood resilient spatial planning depends on the depth of a flood: When floods are deep they can simply exceed the mitigating capacity of second layer measures. Therefore, the action perspectives for shallow floods are considerably different from the action perspectives for deep floods. The Klimaateffectatlas (2019) distinguished between four different categories of flood depths to which different action perspectives are linked (figure 20). As the flood depths increase, the possibilities and opportunities for second layer measures decrease. Flood depth is therefore an indicator that indicates if, and what kind of measures of flood resilient spatial planning are possible, as illustrated in figure 20.

Legend map:	0-20 cm	20-50 cm	50-200 cm	200-500cm >500cm
Examples of possible second layer measures:	▪ New constructions: elevated construction, modified doorstep heights. ▪ Existing constructions: arrange emergency measures such as door beams and sand bags.	▪ New constructions: modified doorstep heights, elevated electricity connections. ▪ Existing constructions: structural measures are expensive and difficult.	▪ New constructions: elevated entrance. ▪ Existing constructions: structural measures are expensive and difficult.	▪ New constructions: consider planning collective provisions and facilities. ▪ Existing constructions: check the availability of elevated safe zones nearby.
Target image:	No water in objects	Limit damages	Shelter inside houses	Sufficient shelter capacity & evacuation possibilities

Figure 20: Action perspectives for various flood depths (source: modified from Klimaateffectatlas, 2019).

6.2.2 | An indicator of preparedness

An important indicator of resilience in being prepared, is the degree of water awareness. Preparedness and awareness are the two key aspects of 'social resilience' or 'resilient communities' (Interview 3, 2019). Important means that foster the latter are stakeholder involvement and participation (Interview 8, 2019). Due to the increasing relevance and -role of local non-state actors, such as citizens and communities, in flood risk management (Forrest et al., 2018), stakeholder participation can be regarded as an indicator of resilience. Back in 1969, Sherry Arnstein distinguished between eight levels of stakeholder participation in her famous ladder model (figure 21), which can be used to assess or quantify the degree of stakeholder participation. Unmistakably, resilience demands one of the higher ranks of stakeholder participation in this model.

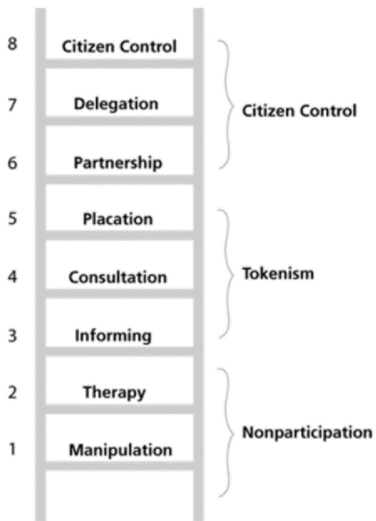

Figure 21: Ladder of citizen participation (source: Arnstein, 1969).

6.2.3 | An indicator of adaptability

A determining indicator of resilience in being adaptive or flexible, is the adaptive capacity of institutions (Interview 8, 2019). The concept of adaptive capacity of institutions "encompasses the characteristics of institutions (formal and informal; rules, norms and beliefs) that enable actors (individuals, organisations and networks) to cope with climate change, and the degree to which such institutions allow and encourage actors to change these institutions to cope with climate change" (Van den Brink et al., 2014, p.982). In their article, Van den Brink et al. (2014) developed a comprehensive diagnostic tool and methodological framework – the Adaptive Capacity Wheel - which is able to assess the adaptive capacity of institutions (figure 22). This model consists of twenty-two criteria as indicators of adaptive capacity, divided over six dimensions, which makes it capable of revealing institutional bottlenecks (Van den Brink et al., 2014). Please consult this specific article, as well as the articles of Gupta et al. (2008; 2010) and Van den Brink et al. (2011) for a theoretical underpinning and an in depth explanation of all the components of this framework, as this Adaptive Wheel provides a clear and structured overview of the adaptive capacity of institutions, as an indicator of resilience.

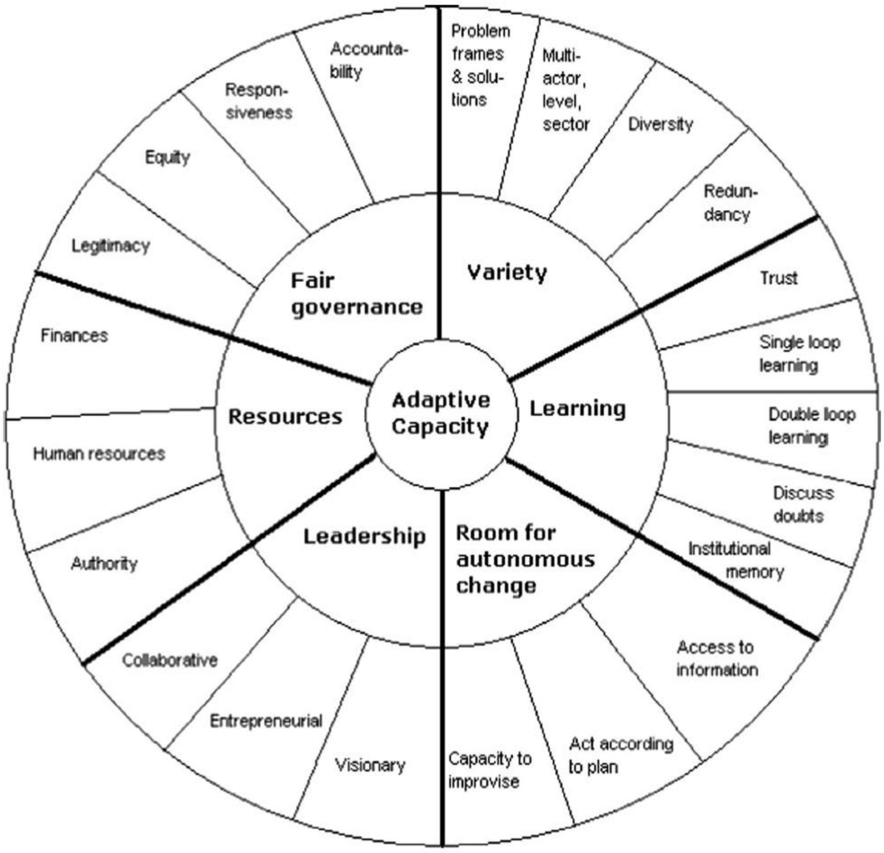

Figure 22: The Adaptive Capacity Wheel (Source: Van den Brink et al., 2019).

6.2.4 | An indicator of transformability

Indicators for resilience in terms of transformability have not been found in this thesis due to the lack of targeting issues found in Dordrecht and de IJssel-Vecht Delta, both in the spatial-physical dimension and the institutional-organizational dimension. Once again; in this we can find a recommendation for future research.

6.3 | The barriers for flood resilient spatial planning

After the extent of resilient spatial planning in the case of the island of Dordrecht and the IJssel-Vechtdelta have been investigated in chapter 5, some rough conclusions can be drawn. On a positive note, there are clear sings of the good intention and efforts towards the second layer of the MLS concept – illustrated by the development of the FRSPI models (figures 17 and 18). The awareness of the importance of the subject is most certainly present, especially at the administrative level. Recently, this was objectified with the national Delta Plan on Spatial Adaptation of 2018. At this moment, it is key that consequence reduction of floods becomes a core issue of the area-based execution of the three ambitions as expressed in this Delta Plan: the stresstest, the risk dialogue, and subsequently the development of concrete measures (Deltacommissaris, 2018).

On the other hand however, there remains a large gap between the potential and wide array of measures and strategies of flood resilient spatial planning possible in theory, and those realized in practice. Many of them are labelled as being additional, on top of the first layer measures, and rather long term ambitions. Therefore, realized examples of flood resilient spatial planning are scarce (Interview 4, 2019). The results of the primary and secondary data analysis are therefore largely in line with the conclusion of 2019s Delta Programme, that the execution of the second layer of the MLS approach is currently insufficient and that progress lags behind. Also this analysis revealed clear signs of a lack in the adoption of a discourse by a wide range of relevant actors (discourse structuration); a lack in the solidification of the discourse into arrangements and organizational practices (discourse institutionalization); and certainly the lack in the awareness of flood risk, as was earlier identified by Hajer (1995) and Kaufman et al. (2016). This large gap between theory and practice is the result of an extensive list of persistent barriers attached to many of the second layer measures. This brings us directly back to the central research question of this thesis, because what are those barriers? Generally, we can distinguish again between the spatial-physical dimension and the institutional-organizational dimension.

6.3.1 | Spatial-physical barriers for flood resilient spatial planning

- **Maximum flood depth:** The most important spatial-physical barrier for flood resilient spatial planning is that the maximum flood depth of an area simply can exceed the mitigating capacity of second layer measures. As flood depths in the Netherlands in general are relatively deep, opportunities for the second layer of the MLS approach are limited (Interview 4, 2019; Interview 5, 2019). The maximum flood depth determines the degree in which an area is exposed to the effects of a flood and therefore a big determinant in the extent of damage and casualties (Klimaateffectatlas, 2019). Maximum flood depth therefore should be the starting point when considering second layer measures (figure 23):

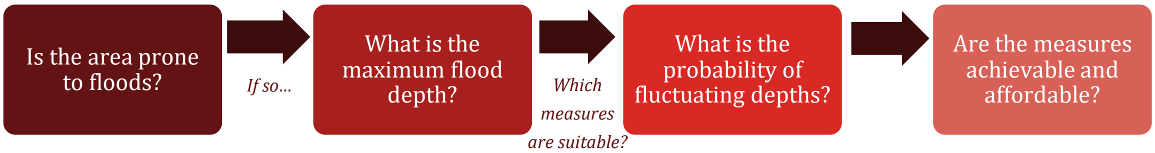

Figure 23: Are second layer measures necessary and possible? (source: modified from Klimaateffectatlas[1], 2019).

Figure 24 on the next page shows the maximum flood depths of Dordrecht (A) and the IJssel-Vecht Delta (B). A similarity between the two regions is that the largest share of flood risk is directly coming from the primary water system, which results in large potential consequences (Interview 5, 2019). In figure 24 this is well illustrated by the fact that for a large extent of both regions, the maximum flood depth will reach or exceed two meters. In this case reducing flood consequences through resilient spatial planning is almost certainly impossible. Structural second layer measures to alleviate damages are already limited and expensive when flood depths exceed 20 centimetres. Those regions should focus on guaranteeing sufficient and accessible evacuation routes and elevated safe zones (Interview 2, 2019, Interview 4, 2017; Interview 7, 2019; Klimaateffectatlas, 2019).

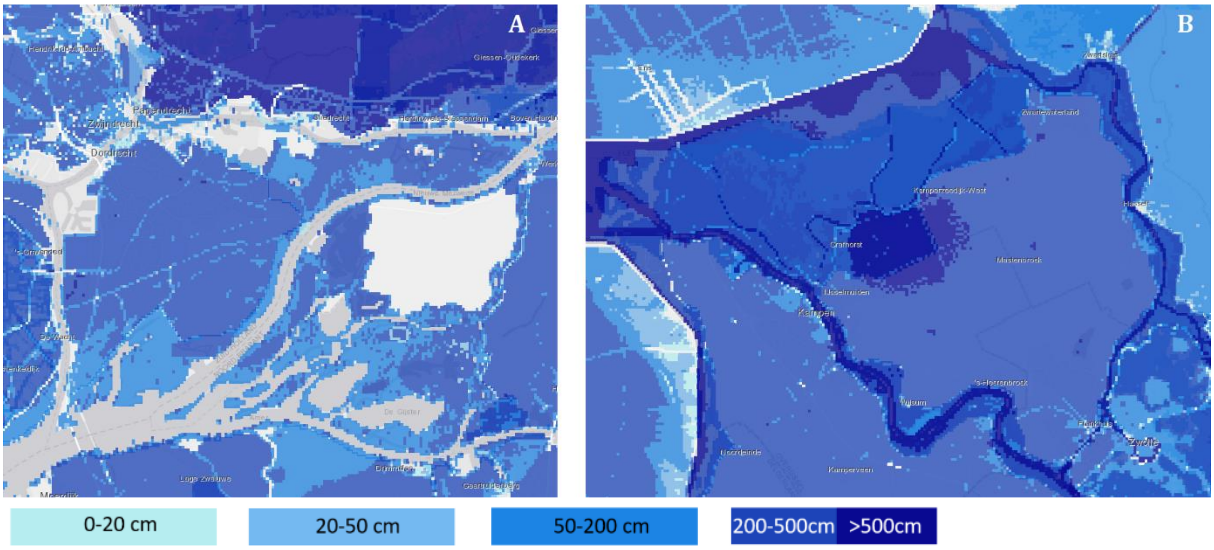

Figure 24: Maps showing the maximum flood depths of Dordrecht (A) and the IJssel-Vecht Delta (B) (source: modified from Klimaateffectatlas, 2019).

- **Rigidity of the built environment:** A second important determining factor for the opportunities for flood resilient spatial planning relates to the spatial development at hand: does it concern new construction, or existing construction? (Interview 5, 2019; Klimaateffectatlas, 2019). It is just difficult to transform an already existing and build-up area into something new (Interview 2, 2019; Interview 3, 2019; Interview 7, 2019). An important barrier for resilient spatial planning therefore is the rigidity of the already existing built environment. Therefore, the current Dutch water management system shows clear symptoms of lock-in and path dependency, as described by Harries & Penning-Rowsell (2011), Jeffers (2013), Restemeyer et al. (2017) and Leichenko et al. (2019), in chapter 2.

- **Lack of space:** Relating to the previous mentioned barrier; in a relatively small and densely populated country like the Netherlands, a barrier for second layer measures is sometimes the simple lack of space. Most certainly in urban environments such as Dordrecht and Zwolle, this is an often perceived spatial-physical barrier (Interview 1, 2019; Interview 4, 2019; Interview 8, 2019; Interview 9, 2017).

5.1.2 | Institutional-organizational barriers for flood resilient spatial planning

- **Safety perception, risk awareness and urgency:** The Netherlands has a long history of fighting- and accommodating water. The Dutch water management sector has been so successful in this mission that water experts, policy makers and citizens have a very high perception of safety behind the first layer of protection: the dikes, dams, and storm surge barriers (Deltacommissaris, 2018). The high safety perception results in a general low awareness that flooding comes with serious risks: the fact that not only flooding from rivers of the sea, but also extreme precipitation can lead to floods, and the fact that the potential effects, aftermath and recovery of a flood can be of tremendous proportions (Deltacommissaris, 2018). The safety perception and risk awareness of water disturbance and floods definitely penetrated into the administrative level over recent decades. However especially for the general public, the safety perception, risk awareness and therefore urgency is non-existing, low, or false, resulting in little own initiatives towards climate change adaptation (Interview 2, 2019; Interview 3, 2019; Interview 7, 2019). Taking on board these stakeholders, such as real estate developers, private property owners and businesses, is however crucial for enhancing the water resilience of a system (Interview 3, 2019) simply because the biggest share of land surface is privately owned (Interview 9, 2019). Awareness about urgency is the first – but very difficult - step towards preparedness to act (Interview 1, 2019; Interview 5, 2019; Interview 9, 2019).

- **Political and societal support:** As a direct consequence to the low or false safety perception, risk awareness and therefore urgency to act, is the political and societal support towards flood resilient spatial plans. Over the past decades a lack of awareness resulted in a lack of preparedness: the political and societal basis for plans was often insufficient. Fostering this basis and support is however crucial, because the chain is as strong as the weakest link of the system (Interview 9, 2019).

- **Sectoral approach versus integration:** The water sector and the spatial planning sector are two worlds apart. The core aim of water managers is to guarantee water safety upon which they largely rely on traditional instruments and measures: primary flood defence mechanisms such as dikes, dams, storm surge barriers, sluices and pumping stations. In the spatial planning sector this is often perceived as a 'given', therewith obstructing attention to flood risk. Also within the two sectors many sub-sectoral divisions (e.g. water safety, water hindrance, water quality, crisis management, etc.) hamper an integral effort to address the consequence reduction of flooding, as each work with its own policies, legislation, and authorities (Deltacommissaris, 2018). Thinking about water resilience requires a drastic change in the way important stakeholders collaborate, as sectoral blockades need to be breached: a time consuming and very difficult task (Interview 1, 2019). In the IJssel-Vecht Delta program close- and cross sectoral collaboration has been a strong asset. A few times a year a steering group broadly representing the region came together to go through the most urgent dilemmas. Throughout the process only rarely did major problems arise (Interview 9, 2019). Nevertheless, integration is not the panacea to all the problems perceived. In fact a full cross-sectoral integration is often undesirable as it inevitably results in endless negotiation, planning, and decision making processes (Interview 1, 2019; Interview 8, 2019). Therefore, on the one hand integration is a means that should be pursued, on the other hand it could form another barrier to resilient spatial planning.

- **Responsibility ambiguity:** to a certain extend directly related to the previous barrier, is the ambiguity regarding responsibilities. The various stakeholders that play a role in achieving flood resilient spatial planning (e.g. provinces, municipalities, water boards, safety regions, citizens, companies, etc.) are numerous and are all acting from their own responsibilities and interests (Interview 4; 2019, Interview 5, 2019; Interview 8, 2019). Often, stakeholders are standing with their backs to each other: water safety, recreation, energy, etc. Then how can this be translated into one resilience-enhancing strategy, and who is responsible for what? Both for the construction, but especially also for the long term enforcement and maintenance (Interview 1, 2019; Interview 6, 2019; Interview 7, 2019).

- **Finance and the (temporal) cost-benefit imbalance:** Flood consequence reduction is not in the slightest a beloved activity of spatial planners due to the fact that it costs money and due to the temporal imbalance between costs and benefits (Deltacommissaris, 2018; Interview 9, 2018). This financial aspect might be considered as the largest institutional-organizational barrier to the second layer of the MLS concept. In almost all instances the construction and maintenance of second layer measures cost money, and in a vast majority of cases the benefits simply do not outweigh the costs and/or there are alternatives at hand that are more efficient and effective (Interview 2, 2019; Interview 3, 2019; Interview 4, 2019; Interview 5, 2019; Interview 7, 2019; Interview 9, 2019), or there is a lack of urgency to act at all (Interview 3; 2019). On a short time scale, measures that foster resilient spatial planning to flood risk appear to yield limited benefits, as their goals is further reduce risks of flooding. At the same time there are alternative strategies at hand of which their presence and effects may be more visible: investments in the first or third layer of protection for example. Over recent years there have been numerous examples where the advices of water managers are overruled by short term financial arguments (Deltacommissaris, 2018; Interview 3; Interview 8).

- **Human capital:** A final observed institutional-organizational barrier for flood resilient spatial planning is (the lack of) human capital: expertise, skill, or the amount and availability of personnel. The fruition of the MLS concept and its second layer inside a region, are often in the hands of only a handful of enthusiastic people inside a governmental or private organization. When those people are not available, processes such as climate change adaptation and flood resilient spatial planning do not get off the ground (Interview 4, 2019; Interview 5, 2019). As testing grounds of the MLS concept, the island of Dordrecht and the IJssel-Vecht Delta do not struggle with this human capital barrier, but many regions in the Netherlands do (Interview 4, 2019).

6.4 | Breaching the barriers, by using the opportunities

After identifying the barriers of flood resilient spatial planning, the logical and relevant follow up step is to investigate how these barriers can be breached. Logically, the utilization of the opportunities for the second MLS layer play an important role in this. Two questions are therefore central in this section: how can the barriers be breached, and what are the opportunities for flood resilient spatial planning? Exactly these two questions have been asked during the workshop on the C5a GCM in Ringkøbing, Denmark. Results can be found in table 5 below. Answering these two questions summarize the key findings of the case of Dordrecht and the IJssel-Vecht Delta into 'key lessons' for the broader uptake and embodiment of flood resilient spatial planning to flood risk, and can therefore be seen as the recommendations following from this master thesis.

Barrier	Solutions and opportunities
Maximum flood depth	This barrier was particularly difficult to breach according to the participants of the workshop, as the maximum flood depth is an intrinsic 'given' of a system and cannot easily be altered. Accepting the limited adaptive capacity with regards to this barrier is therefore necessary. Nevertheless the solutions to breach this barrier could potentially be found by making the division between the urban and rural, as this is a determining factor for the array of measures possible. In an urban environment regulation for adaptive building or the designation of safe areas were mentioned as solutions. In rural environments more could be done with spatial planning and spatial configurations (e.g. dwelling mounds).
Rigidity of the built environment	The first step in breaching this barrier given by the participants of the workshop was defining high risk areas, as based on this decisions can be made if uses accept the risk or should move. Changing the use of buildings will cause new requirements.
Lack of space	The barrier of a lack of space can be breached by expanding cities. With use of enhanced spatial planning and cross-sectoral thinking, smart combination of functions can be sought for (e.g. the parking garage in Katwijk was mentioned as example). Bottom-up approaches should make inhabitants consider what they can do themselves.
Safety perception, risk awareness and urgency	The participants of the workshop agreed that the first step towards breaching this barrier is being honest about safety and risk: provide more and better communication with the general public to increase engagement. This can furthermore be increased by making all three layers of the MLS approach more visible.
Political and societal support	The participants of the workshop identified the close relation between this barrier and the previous, as the solutions correspond. The first step is awareness raising. Initiatives on a local (neighbourhood) level can foster the engagement of the broader public. The main question here seems to be how we can incentivise stakeholders: especially the private sector. To achieve this, risks and vulnerabilities have to be assessed and communicated at a finer scale. The problems has to be more 'owned' by private actors.
Collaboration: sectoral versus integration	The participants of the workshop emphasised that there will always be conflicts in the interests and objectives of stakeholders, despite the degree of integration. Crucial for a successful collaboration is therefore that flood resilient spatial planning becomes something that stakeholders really 'want'. A special taskforce primarily focussing on this collaboration process could safeguard and optimise this.
Responsibility ambiguity	The problem of unclarity in responsibilities was something that the participants of the workshop recognized. They emphasised that governmental elections hamper this situation. Furthermore, a lack of financial resources often instigates the responsibility ambiguity: stakeholders do not want to be responsible to pay for the measures. Clear solutions other than raising awareness were not opted by the participants of the workshop.
Finance and the (temporal) cost-benefit imbalance	The participants of the workshop recognised that this barrier is one of the most important. However, unfortunately it also is one of the most difficult to solve. There were no solutions given during the workshop that could breach this barrier.
Human capital	The barrier of a lack of expertise, knowledge, skills and manpower could be breached by arranging this more centralised. The participants of the workshop were in favour of creating 'clusters of knowledge' and bring the decision-making regarding the second MLS layer back to state-level.

Table 5: Answers given to the question "How can the barriers to flood resilient spatial planning be breached, and what are the related opportunities for flood resilient spatial planning?" during the workshop on 21-06-2019 in Ringkøbing (Denmark) on the GCM of the Interreg C5a Project. Disclaimer: the 15 participants of the workshop were split up into duos or trios, and each group got assigned one or two barriers to solve these two questions for. Some of the results and generalizations in this table therefore need to be treated with caution. For example the statements that "no clear solutions to this barrier were given", does not necessarily imply that by definition there are no solutions at all, but can most likely be explained by the fact that the participants had a limited amount of time to work on these questions or had insufficient knowledge about the specific barriers (source: Author, 2019; based on the Workshop, 2019).

Based on the analysis of scientific literature, policy documents, expert interviews and workshop results, the first step in breaching most of the institutional-organizational barriers is generating the awareness that the topic of climate change adaptation deserves (Workshop, 2019). The facts speak for themselves: while climate change and urban and economic growth increase flood risk and vulnerability of coastal and deltaic regions like the Netherlands, too little efforts are made to reduce and mitigate the consequences of potential floods (Deltaprogramma, 2019; Van der Voorn et al., 2017). Everything therefore starts with awareness. Achieving risk awareness will result in a just safety perception, and therefore in urgency and preparedness to act (Interview 5, 2019). This awareness should not only be broad in the public sector with policy makers and civil servants (therewith addressing the barrier of the lack of human capital), but also in the private sector. The general public, individual households, businesses and companies should not solely trust on their governments, but should recognise and acknowledge opportunities to actively pursue climate change adaptation themselves. The active and early involvement of important stakeholders in the decision making process, is a means to foster this awareness and therefore also the preparedness to make long term investments (Interview 3, 2019). Important here is that these private parties also see the positive side of climate change adaptation, as a lot of measures bring added value to the people's neighbourhoods and houses (Interview 7, 2019; Interview 9, 2019). The stresstest and risk dialogue as developed in 2018's Delta Plan on Spatial Adaptation are already existing instruments that can operationalize this entire process. Whereas the stresstest is able to expose vulnerable areas regarding precipitation, heat, droughts and floods, therefore generating awareness, the risk dialogue between important public and private stakeholders stimulates involvement and preparedness (Deltaplan Ruimtelijke Adaptatie, 2018). In the upcoming years it is important that the potential of these two instruments if fully seized, which requires the active attitude and application from government administrations. Establishing an effective and efficient collaboration between private and public sectors and governments over multiple levels is an important means to facilitate the spreading of awareness and preparedness as a first step for the flourishing of the second layer of the MLS concept. In this collaboration it is important to seek for a fair balance between addressing flood resilient spatial planning sectorally or in an integrated manner. Currently, the lack of the latter seems to predominate. Water boards, provinces, municipalities, but also real estate developers, architects and the general public should incorporate water resilience more consciously (Interview 7, 2019). Nevertheless, it is important not to pull the long bow regarding this integration, as this often results into lengthy plan and policy making procedures, and can aggravate responsibility ambiguity (Interview 1, 2019). Subsidiarity is therefore key.

Nonetheless, thinking that awareness and preparedness directly lead to action is a misconception. The financial barrier to flood resilient spatial planning plays an important role in this (Interview 1, 2019; Workshop, 2019). The cost-benefit balance of second layer measures is often negative. There is a lack of a clear policy framework or juridical instrument that helps in the consideration of the acceptability of a potential increase in flood risk (Deltacommissaris, 2018). Whereas the national financing structure of first layer measures is relatively well organised with the national Delta Fund, such arrangements lack for second layer measures. However, the upcoming Delta Law of 2020 is most likely changing this with the incorporation of second layer measures into the Delta Fund (Interview 2, 2019). A prerequisite for breaching the financial barrier is to never work solely for climate change adaptation, but always look to work integrally and to link it to other developments and challenges of the region, such as the energy transition, the housing shortage, or the revitalization of neighbourhoods. Also here, emphasizing the potential of generating added value to houses, neighbourhoods and regions is key (Interview 8, 2019; Interview 9, 2019): replacing hardened, paved surfaces by green-blue infrastructure for example does not only foster rainfall infiltration capacity, but comes with co-benefits as it also improves the general quality of neighbourhoods, with positive side effects for human health, flora and fauna (Interview 1, 2019). Furthermore, it is important to provide a clear sketch of the potential consequences when flood resilience enhancing spatial adaptation measures are not taken (Interview 8, 2019). Framing is therefore a decisive factor in the success or failure of climate change adaptation measures. Due to the weak profile and the long-term nature of flood resilient spatial planning, the topic is not 'sexy' among policy makers and the general public. Developing attractive long-term visions that emphasise integrality and the seizure of synergetic opportunities is therefore very important in this framing process. Additionally; framing is considerably fostered by making use of good and positive examples (Interview 2, 2019; Interview 5, 2019). As focus areas and pilot regions for MLS in the national Delta Programme, both the island of Dordrecht and the IJssel-Vecht Delta feature an abundance of such examples (see figures 17 and 18). Make use of them as showcases to inspire other regions in the Netherlands, as example is better than precept. Both cases understood this well: the city of Dordrecht collaborates with an international architectural biennial to develop an attractive vision that fosters a fairer risk perception and stresses synergies between climate change adaptation measures and improving the social cohesion and outlook of neighbourhoods (Interview 2, 2019), whereas the IJssel-Vecht Delta continuously updates visual and attractive project books, easily accessible to the general public.

Hitherto, this section proposed some important starting points for breaching important barriers for flood resilient spatial planning. However, all the so far proposed solutions are all aimed at breaching the institutional-organizational barriers. Solutions for the three spatial-physical barriers (maximum flood depths, the rigidity of the built environment, and the lack of space) are more difficult to find. Hence they form the most important restrictive factor for the opportunities for the second layer of the MLS approach (Workshop, 2019). The three spatial-physical barriers are intrinsic characteristics of a system, and opportunities to alter them are limited. When searching for opportunities for flood resilient spatial planning to be (most) successful, these spatial-physical barriers are taken as a starting point:

- **Frequent, regional and shallow floods:** Second layer measures are most – if not only – effective for relatively shallow maximum flood depths. There simply is a limit to the effectiveness of measures such as water retaining green-blue infrastructure, dwelling mounds, water blocking baseboards and other modifications to buildings. When the maximum flood depth exceeds more than a meter, most of the second layer measures simply do not work or are in sheer cost-benefit imbalance (Interview 4, 2019; Interview 7, 2019). As the Klimaateffectatlas (2019) illustrates, opportunities for flood resilient spatial planning can mainly be found for water disturbance and floods below 20 centimetres. As compared to the primary water system, floods from the regional water system are often more frequent, though more shallow. Here, opportunities for second layer measures can be found (Interview 5, 2019; Interview 6, 2019). Hence, there appear to be greater opportunities with regard to pluvial flooding, as compared to coastal- and fluvial flooding.
- **New developments:** There are limits to the extent that an already existing system can change. Especially for the island of Dordrecht, the three identified spatial-physical barriers are very restrictive for the opportunities of flood resilient spatial planning (Interview 2, 2019). Flood proofing pre-existing built up environments is an extremely cost intensive activity and often in instead of taking measures to each individual building, in those cases it is more efficient to invest in integral measures that protect the entire region (Interview 4, 2019). This is different with regards to new development and construction. When adopted early on in the decision- and planning process, the costs of second layer measures such as water blocking baseboards or the obligation to have skylight windows, can be limited. For new developments, there are definitely more opportunities for flood resilient spatial planning to be successful (Interview 6, 2019).
- **Synergistically integrated:** The only opportunity in which flood resilient spatial planning seems to be feasible is under the condition that it is linked to other developments in the area. There needs to be a synergetic integration between second layer measures and further challenges in a region (e.g. energy transition, neighbourhood revitalization, the sustainability ambition, etc.) to generate sufficient awareness, urgency and preparedness to act (Interview 2, 2019; Interview 8, 2019). After all, second layer measures such as green-blue infrastructure have the potential to add value to regions and neighbourhoods, and while tied to other developments, also the costs of climate change adaptation can be reduced (Interview 5, 2019).
- **Better use of unused areas:** A large opportunity is that flood resilient spatial planning can enable a better use of unembanked regions; those that are outside of the protection of primary flood protection measures. Such areas can be found throughout the Netherlands, and at this moment their full potential is not always used optimally. For example in Dordrecht, the unembanked Wantij area has a higher elevation than most parts of the embanked parts of the city, resulting in a lower maximum flood depths. Yet, due to the false risk perception of people that unembanked areas are by definition unsafe, its potential is not used (Interview 2, 2019). This is a shame as unembanked regions throughout the Netherlands also score well on the other two spatial-physical barriers: often there is no (rigid) built environment, and hence not the problematic lack of space. On the other side they often offer attractive development locations in the direct vicinity of water bodies, for flexible and adaptive land-uses (e.g. livestock farming with the farm elevated on dwelling mounds). Of course: not every unembanked location in the Netherlands is suitable for development, as development might contradict with water safety. Unembanked areas for example often fulfil important functions as retention areas for peak water discharges. Nevertheless, here is definitely a substantial opportunity for (sustainable) development.

7 | Conclusion

7.1 | Paving pathways for flood resilient spatial planning

This thesis has two core objectives: socially, it aims to contribute to the progression of the embodiment of more resilient spatial planning to flood risk. Scientifically, it aims to bridge the often perceived gap between theory and practice concerning the MLS concept. By making use of scientific literature on complex adaptive systems and socio-ecological resilience, and the subsequent development of the FRSPI model, both the presence and absence of flood resilient spatial planning was scrutinized for the case of Dordrecht and the IJssel-Vecht Delta. Prior to answering this central research question, a range of subquestions have been dealt with.

7.1.1 | What is flood risk, and how is it managed?

This thesis described flood risk by dissecting the flood risk approach formula (figure 5). This defines flood risk as the hazard probability multiplied by the consequences of a flood. Up to the 1990's flood risk was managed with a strong focus on minimizing hazard probability, often by means of hard, technical measures. Since the 1990's, flood risk management in the Netherlands is going through a transition, and a new, broader, integrated and holistic water paradigm emerged, which addressed both sides of the formula: both the hazard probability and also the consequences of floods (Woltjer & Al, 2007; Schoeman et al., 2014; Restemeyer et al., 2015; Van Veelen, 2016). In this, the objective expanded from water resistance, towards water resilience.

7.1.2 | What does it mean to be resilient?

'Resilience' is a fuzzy term covered in ambiguity. Although the term originates from mechanics and engineering, as this thesis described socio-ecological systems in deltaic and coastal regions as complex adaptive systems, this thesis took socio-ecological resilience as starting point (Spaans & Waterhout, 2017). This describes resilience as the "ability of complex socio-ecological systems to change, adapt and [...] transform in response to stresses and strains" (Davoudi, 2012, p.302). Over past years, there is a growing consensus that resilience has four key components: persistence, preparedness, adaptability and transformability (Folke, 2006; Davoudi et al., 2013).

7.1.3 | What does the MLS concept, and its flood resilient spatial planning entail?

Since 2009, the Dutch government aimed to achieve water resilience by employing the Multi-Layer Safety concept (Ministerie van Infrastructuur en Waterstaat, 2015). This concept distinguishes between three 'layers', which jointly constitute an integrated water management approach: (1) flood protection: focussed on reducing flood risk probability through flood defense infrastructure; (2) resilient spatial planning: minimising the consequences of a flood by pursuing proactive spatial planning and flood-proof spatial designs; and (3) crisis management: minimising the consequences of a flood, by enhancing crisis management (Klostermann et al., 2014). Despite continuous efforts made in the first layer, and increasingly in the third layer, the flood resilient spatial planning (layer 2) remains an eyesore. Flood risk consequence-reducing measures through adequate spatial planning are barely considered in Dutch flood risk management. "The lack of measures in the field of spatial planning [...] portraits the current one-track approach, focused on reinforcing levees and dikes, instead of an integral risk reducing policy" (Leskens et al., 2013, p.2).

7.1.4 | What are the barriers and opportunities for resilient spatial planning in flood risk management?

The latter brings us directly to the central research question of this thesis: "*What are the barriers and opportunities for resilient spatial planning in flood risk management?*" First of all: the underlying problems to the initial research objectives were clearly identified in data research and analysis of this thesis, and results from the data analysis of this thesis are therefore in line with conclusions of the Delta Programme (2019): the realization and effectuation of second MLS layer measures is rather limited and lacks progression. Also the gap between theory and practice was identified: there is a large difference between the wide array of measures and strategies that are possible in theory, and those that are actually realized in practice. This large gap is the result of an extensive list of persistent barriers attached to many of the second layer measures. This thesis identified six institutional-organizational barriers: a false, low or non-existing safety perception, -risk awareness, and therefore urgency to act (1), a lack of political and societal support (2), a suboptimal condition of collaboration between important stakeholders do to an imbalance between integration and a sectoral approach (3), ambiguity and uncertainty regarding responsibilities (4), finance and the (temporal) cost-benefit imbalance of second layer measures (5), and a lack of human capital (6). Additionally three spatial-physical barriers for flood resilient spatial planning were found: deep maximum flood depths (7), a lack of space (8), and rigidity of the pre-existing built environment (9). Breaching these barriers can pave the pathways for flood resilient spatial planning, as it contributes to the progression of the embodiment of more second layer answers to flood risk, and could be a foundation for the bridge over the theory-practice gap.

7.1.5 | How can we deal with those barriers and opportunities?

Although difficult, the institutional-organizational barriers are surmountable. In terms of solutions, a lot of the institutional-organizational barriers are interrelated. Flood resilient spatial planning stands or falls by awareness. Currently, a false, limited or non-existent risk-perception restricts the sense of urgency to act. Being honest about flood risk, clearly communicating this risk to the general public, and actively and early involve important stakeholders in the decision making process, is a means to foster this awareness and therefore also the preparedness and political and societal support to make long term investments. The stresstest and risk dialogue as developed in 2018's Delta Plan on Spatial Adaptation are already existing instruments that can operationalize this entire process. In the upcoming years it is important that the potential of these two instruments if fully seized, which requires the active attitude and application from government administrations. On the other hand, the general public should become more engaged into climate change adaptation by making them more a problem owner. Bottom-up approaches and local initiatives (such as 'SensHagen' in Zwolle) should make communities more aware of what they can do themselves. Apart from the (lack of) awareness, there are further governance problems obstructing flood resilient spatial planning. Generally a lack of horizontal and vertical integration was identified within and between governments and private parties. Water boards, provinces, municipalities, but also real estate developers, architects and the general public should incorporate water resilience more consciously. To conclude with the most persistent institutional-organizational barrier: finance. Second layer measures cost money, and their cost-benefit balance is often (temporally) negative. There are simply better alternatives at hand, with first and third layer measures, and flood resilient spatial planning is often overruled by short term financial arguments. A prerequisite for breaching the financial barrier for second layer measures is to never work solely for climate change adaptation, but always look to work integrally and to link it to other developments and ambitions of the region. Emphasizing the potential of generating added value to houses, neighbourhoods and regions is key, and can mitigate the persistent financial barrier.

The spatial-physical barriers are on the other hand more problematic to breach, as they are intrinsic characteristics of the system that are arduous to alter. Pre-existing built-environment is rigid and constrains opportunities for flood resilient spatial planning. Furthermore, maximum flood depths in the Netherlands are generally very deep and can easily exceed two meters. Opportunities for flood resilient spatial planning are just limited, as deep maximum flood depths can simply exceed the mitigating capacity of second layer measures. Hence, the spatial-physical barriers form the most important restrictive factors for the opportunities for the second layer of the MLS concept.

7.1.6 | Future outlook

After opposing the barriers to the opportunities for flood resilient spatial planning, it is time to take stock: what is the future of second layer measures of the MLS concept? Is it too expensive, insufficiently mitigating the consequences of floods, or obstructed by a whole range of other spatial-physical and institutional-organizational barriers, and should we abandon pretensions about this second layer in our three-fold MLS approach altogether? Or are there still sufficient leads in the opportunities for flood resilient spatial planning to cling on to?

Like with the majority of questions, there is no straightforward answer, because there is truth in both ends of the spectrum. However, in all fairness, it must be admitted that the barriers for resilient spatial planning in flood risk management are abundant and persistent, whereas the opportunities are limited. Frankly, the perceived gap between theory and practice is only very logical after all. In theory, the threefold MLS approach provides the Netherlands with a broad, comprehensive strategy to keep our feet dry, but in practice this approach is obstructed by cogent and rational practical doubts and arguments. Of course we are not going to completely flood proof one object inside a dike ring if for the same amount of money all the object inside that dike ring can be protected by enforcing the dike ring itself. Of course we are not going to demolish districts and neighbourhoods to reconstruct them on a newly created dwelling mound. And of course, we are not going to install flood proof baseboards in front of doors for flood events with a very low probability but with a maximum flood depth of multiple meters. Scientifically and theoretically, the aspirations and expectations of what flood resilient spatial planning can achieved need to be tampered. After all, it should not be forgotten that the layers inside the MLS concept are not interchangeable. They are complementary, with the first layer being the most important as a robust basis, and second- and third layer measures purely additional.

Does this mean that we can bin the entire second layer of the MLS approach and from now on only focus on the first- and third layer? No. Although limited, there are definitely several opportunities for flood resilient spatial planning. The preconditions to these opportunities are that it is most – if not only – effective for relatively shallow maximum flood depths: opportunities for flood resilient spatial planning can mainly be found for floods and flooding below twenty centimetres (figure 20). As compared to the primary water system, floods from the regional water system are often more frequent, though more shallow. Here, opportunities for second layer measures can be found. Furthermore, there are opportunities when the measures regard new developments, since when adopted early on in the decision- and planning process, the costs of second layer measures can be reduced, and the problem of rigidity and path-dependency of the pre-existing built-environment is less constraining. Summing up these preconditions, a big opportunity for flood resilient spatial planning is that it can allow a better use and purpose for those zones that are currently not optimally used, such as areas outside embanked areas, for example the Wantij Zone in Dordrecht.

7.2 | Reflection on this thesis

After many hours, days, weeks, and months of reading, collecting data, transcribing, analysing and writing, this thesis is approaching its end. Therefore, a thorough reflection on the entire process can take place. Some aspects of the process went very well, others more difficult, but despite the surmountable ups and downs, I look back at the past months and the end product predominantly satisfied.

On a positive note, I gained great experiences over the past months. Not only in terms of content specific knowledge, but especially due to the entire process of interning at Rijkswaterstaat for the Interreg C5a project. This gained me working experience, improved my professional network, my (verbal) communication skills and persuasiveness. My planning and organization of the entire process was another positive note in my opinion: due to constantly fore- and backcasting my progression, all deadlines were adhered to. Directly related to the process of writing a thesis, the primary data collection process springs to mind first as a strength of this thesis. I was very lucky to receive quick and positive response from experts for interviews. Furthermore, the Group Coordination Meeting of the C5a Project in Ringkøbing, Denmark, has been absolutely valuable. Not only did we discuss interesting topics, and was I allowed to present my preliminary thesis, I also received direct primary data input during a workshop that I organized. Content related, I am most satisfied about the fact that I can actually answer the initial research question. Especially finding and developing the concrete list of barriers was gratifying.

On a negative note, there are definitely aspects in this thesis that could have been improved, both process- and content-wise. Despite the fact that the feedback I received from my supervisors was truly helpful, it was not always easy to receive and process feedback from four different supervisors. Content-wise I made a mistake that I have made before: maybe I was too ambitious with the extent of the research scope. I tried to narrow it down by choosing two specific case study regions, but nevertheless it remained difficult to give both a fully and thorough in-depth analysis. This resulted into – in my opinion – strong descriptive results, discussions and conclusions, but ideally I would have liked to be able to further elaborate and deepen my recommendations on indicators of resilience and solutions and opportunities for flood resilient spatial planning. Two notes regarding my methodology have to be made: First of all, due to restrictions in the time and scope of this master thesis, I could unfortunately only scrutinize two cases in depth. The generalizations made with regards of barriers and opportunities is therefore on the basis of only two cases. I acknowledge that this is a drawback of this thesis, nevertheless, this does not make the results less valuable. Furthermore, despite the overall positive influence that the internship at Rijkswaterstaat had on this thesis, a side note with regards to positionality has to be made. Positionality means "recognizing and trying to understand the implications of the social position of the researcher with respect to the subjects, particularly with regard to power relations or cultural differences that may influence the process of the research and its interpretation" (Clifford et al., 2010b, p.534). In my research methodology, I made use of my position and internship at Rijkswaterstaat: a direct stakeholder in resilient spatial planning in flood risk management. This resulted in the disadvantage of a reduced distance between the researcher and the research. Throughout the research, I tried to keep this aspect in mind, to avoid potential biases. For example, seventy percent of all interviewees and workshop participants was *not* affiliated to Rijkswaterstaat. This was a consciously made choice to avoid such biases. Finally, conceptual ambiguity was and remained an obstacle throughout writing this thesis. 'Resilience' is a fuzzy concept, and so are its components 'persistence, preparedness, adaptability and transformability'. Furthermore, MLS measures and strategies were often also hybrid mixtures between multiple layers. Capturing such fuzzy measures under fuzzy components of a fuzzy concept in the FRSPI model was very difficult.

7.3 | Recommendations and future research

During the workshop on the Interreg C5a GCM in Ringkøbing, a final question asked to the participants was which aspects or results of this thesis could foster the cloud-to-coast approach of the affiliated North Sea Region partners. The answer to this question was that the barriers for flood resilient spatial planning were recognized and perceived in broader climate change adaptation strategies of the partners, but that these barriers are insufficiently taken into consideration. By providing a structured account of these barriers, by giving first ideas on how to deal with these barriers, and by opting several opportunities for flood resilient spatial planning, this thesis proves its value to the C5a project, since C5a is developing an integral 'Cloud-to-Coast' adaptation approach that aims to deliver multifunctional and multi-sectoral solutions fostering flood resilience of the North Sea region.

Nevertheless, due to restrictions in the scope of this thesis, and in available time, several aspects of this thesis could not be fully investigated in depth, and therefore provides ground for future research. Three aspects directly spring to mind here: (1) The analysis of Dordrecht and the IJssel-Vecht Delta revealed a general absence of transformability enhancing targeting issues and indicators of resilience. Despite the fact that first ideas regarding this absence were given in section 6.1, it would be valuable if future research could dive deeper into this aspect. (2) Furthermore, section 6.2 *'Towards indicators of resilience'* aimed to develop tangible and measurable indicators of resilience. In itself, this time-consuming activity is a sufficient basis for a whole new thesis. This aspect was beyond the central research question, and therefore scope and aim of this thesis. The examples given in section 6.2 should therefore be seen as exploratory and purely serve as examples. Expanding on measurable indicators of resilience is therefore directly a recommendation for future research. (3) Finally, this thesis provided a solid account of the barriers to FRSP, but ideally the exploration of possible solutions and opportunities for flood resilient spatial planning could have been researched further.

It can therefore be concluded that the tiling of the pathways for flood resilient spatial planning has to be done in future research. Nevertheless, this thesis already provided the tiles and cement.


(Source: Aquaread, 2019)

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