# Identifying barriers and opportunities for the local implementation of urban multi-layer safety towards flood resilience

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Title: Identifying barriers and opportunities for the local implementation of urban multi-layer safety towards flood resilience

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# Abstract

The combination of hydrological hazards linked to the climate crisis and socio-economic developments, such as urbanization, increases the risk of severe flooding events. To address this, a paradigm shift in water management is observable moving from technical command-and-control solutions to protect cities from water towards more integrated and holistic approaches that combine different strategies, such as multi-layer safety (MLS).

Accordingly, this thesis aims to identify barriers and opportunities for the local implementation of the MLS flood risk approach to increase flood resilience in the urban context of Rotterdam. MLS comprises the combination and integration of measures on multiple layers (protection, spatial adaptation, emergency response, (recovery)) to reduce flood risk. The theoretical framework positions MLS as an operationalization of flood resilience. An implementation theory perspective is applied to examine barriers and opportunities for MLS identified in literature.

The central research question '*What are the barriers and opportunities for the implementation of urban multi-layer safety to increase flood resilience?',* is explored through the single-case study of Rotterdam via 11 semi-structured, qualitative interviews with experts involved with implementing MLS reflecting all layers of the approach.

The results show an extensive overview of barriers and opportunities that hinder and foster the implementation in the context of Rotterdam in various ways and how they affect the layers of MLS differently. Also, connections to the individual components of flood resilience as a normative goal are revealed. 'Sectoral fragmentation' and a 'techno-institutional lock-in' are identified as two overarching barriers to which most of the barriers are associated. The opportunities are structured in four categories covering 'pressures', 'MLS in motion', 'mutual gains', and 'available expertise'.

**Keywords**: multi-layer safety · flood resilience · flood risk management · implementation

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## Abbreviations

MLS – Multi-layer safety

FR – Flood resilience

FRM – Flood risk management

IFRM – Integrated flood risk management

FRMS – Flood risk management strategy

CFIR – Consolidated Framework for Implementation Research (Damschroder, et al., 2009)

CAS – Complex adaptive system

SQ – Sub-question

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# 1. Introduction

The anthropogenic, global climate crisis is generally acknowledged, and the impacts are already visible. Spatial planning plays a central role in mitigating this crisis, as well as adapting to the consequential developments like an increasing flood risk (Wilson & Piper, 2010).

Such is the result of several flooding causes that are all expected to amplify with a warming climate. The frequently discussed sea level rise is a main risk for coastal areas (Horton, et al., 2014; Lindsey, 2020; Vitousek, et al., 2017). Additionally, the probability and severeness of extreme weather events like storms and consequent storm surges are predicted to increase, which adds up to the general flooding risk of coastal areas (Rahmstorf, 2017). Furthermore, fluvial flooding due to an increasing river discharge resulting from longer and more intense precipitation periods, is expected to influence the flood risk of riverine areas (Wardekker, et al., 2010), while extreme precipitation also causes further flood risk specifically to urban areas (IPCC, 2014) in the form of surface water flooding due to sealed surfaces impeding infiltration (Jenkins, et al., 2017; Carter, et al., 2018). Urban areas are especially vulnerable to floods because of dense and high population, urban infrastructure, and high economic and socio-cultural values (Cho & Chang, 2017), which creates immense challenges for urban planners.

In the light of these developments a recent paradigm shift in flood risk management (FRM) and planning literature can be observed. Moving away from primarily resisting floods with technical measures and a claim for engineered control, flood resilience (FR) is gaining importance as a holistic flood risk concept. This rather integrative and combined interpretation of living with the water by building adaptive capacity, which is about the social and technical ability to adapt to changes to reduce consequences of flooding, is widely discussed as a suitable way of climate adaptation in the context of FRM (Forrest, et al., 2019; Restemeyer, et al., 2015; Scott, 2013). In line with this shift, a spatial planning perspective gains central importance, because this domain is concerned with the processes of increasing spatial quality for the society and organizing different claims and requirements of space (Neuvel & Van der Knaap, 2010). When flood risk is approached in a more holistic way and becomes an issue with points of contact to various sectors within the urban sphere, spatial planners are pivotal for the organization and governance of such a diverse setting with multifaceted interests.

One approach that is discussed and applied in the context of this paradigm shift is the multi-layer safety (MLS) approach. In line with a more holistic notion of FRM, this approach was developed in the Netherlands and includes three layers of measures to reduce flood risk and increase FR of cities. The approach combines the traditional first layer of flood protection that is characterized by flood defense systems, with measures focusing more on prevention of severe consequences by spatial adaptation as the second layer, and emergency response as the third (Leskens, et al., 2013; Gersonius, et al., 2011). Thus, the MLS approach can be seen as a flood risk management strategy (FRMS) striving towards FR with the aim of minimizing flood damage (Interreg North Sea Region FRAMES, n.d.).

The implementation of such flood resilient, physical, and organizational measures in the urban space and realization of changes in the approach of managing flood risk, require the integration of the traditional water sectors that have been responsible for flood protection, and spatial planning (Restemeyer, et al., 2015). In combination with protective flood measures and disaster response, spatial planning plays a central role in the MLS approach (Lennon, et al., 2014).

## 1.1 Problem statement

Even though the notion of FR and a risk-based strategy like the MLS approach is widely acknowledged, it is still too novel to have been widely implemented and applied. As the shift towards FR is associated with fundamental changes for institutions, spatial planning and design, and structures of governance and responsibilities (van der Brugge, et al., 2005), challenges for the implementation of MLS can be expected. Indeed, prior research shows that the MLS approach remains a rather theoretical concept with a main challenge for implementation within the different responsibilities of the multiple layers (Leskens, et al., 2013). This separation between the areas of practice that reflect the different domains of MLS: water management, spatial planning, and disaster/emergency management, implies an issue of sectoral fragmentation and a resulting lack of coordinated implementation spanning across the layers. In the light of these challenges, the process of applying MLS needs more insights to improve the implementation (van Herk, et al., 2014). This can be provided by identifying and analyzing barriers and opportunities for MLS implementation that complicate or facilitate the ambitions towards FR.

## 1.2 Relevance

### 1.2.1 Scientific Relevance

Urban planning is extensively engaged in the topics of climate change mitigation and climate adaptation, which are increasingly regarded as beneficially related instead of competitive (Grafkos, et al., 2019). To adapt urban areas to climate change and deal with future uncertainties, resilience has recently gained significance and is widely discussed in the field of spatial planning (Davoudi, 2012; Davoudi, et al., 2013; Woodruff, et al., 2018). While the literature pays ample attention to defining resilience in general and FR in specific, less attention has been given to the concept in planning practice and the operationalization for a local, specific context (Shaw, 2012; Wilkinson, 2012 ). Also, challenges occurring from the interdisciplinary character of resilience are understudied in contemporary research (Lu & Stead, 2013).

In literature, it is concluded that a “diversification of FRM strategies contributes to resilience” (p. 1 (Hegger, et al., 2016)) and the need for such diversification of flood management approaches is widely discussed and regarded important especially for urban areas (Lennon, et al., 2014). The MLS approach represents such by combining traditional flood defense, spatial planning/adaptation (reducing impacts in case of flooding), and emergency response (organizational measures in case of flooding) (Leskens, et al., 2013; Gersonius, et al., 2011), to increase FR.

By combining the MLS approach with the examination of the barriers and opportunities for the implementation process, this study provides new insights about the practical application of MLS and addresses a common gap between theory and practice. Furthermore, the focus on the implementation is relevant, because “this area has also been severely overlooked” (p. 539 (Khan & Khandaker, 2016)) This is problematic, as a policy implementation process is an ambiguous and complex interface between theoretical notions and realization, due to a variety of contextual factors, individual decisions, and capacities for implementation (Khan & Khandaker, 2016). Another argument to research the implementation of MLS that addresses the non-linear process of implementation, is the theory of ‘bounded rationality’ that construes a process of decision making as dependent on various internal and external influences and situational circumstances (Simon, 2000).

### 1.2.2 Practical and societal relevance

From a practical and societal perspective, especially the relevance for policy implementation stands out. This is because MLS is not only a theoretical concept, but also adopted to policies like the Dutch National Water Plan from 2009 (Government of the Netherlands, 2009) as well as the current one from 2016 (Government of the Netherlands, 2016). Additionally, EU Floods Directive 2007/60/EC calls for the adoption of a flood management concept, that incorporates an integrated approach (Karrasch, et al., 2021; Hoss, et al., 2013), that should focus on prevention, protection, and preparedness (European Parliament & Council of the European Union, 2007) from and for flood risk. Hence, this general tendency of more integrated and risk-based approaches towards flooding hazards can also be observed in other national policies beyond the Dutch context. To implement such concepts through policies addresses the translation from broad policy visions and goals to the practical world (Khan & Khandaker, 2016), which directly involves companies, citizens, and the role of planners.

Furthermore, studying the barriers and opportunities of the implementation of MLS contributes to urban FR, which contains the possibility for safer neighborhoods and reduced likelihood of fatal consequences due to flooding. Consequently, the society can benefit in uncertain developments in the future that are expected to be influenced by multiple crises and natural disasters. Adding to that, policy- and decision-makers in urban, flood prone areas where the MLS approach has not been practiced yet, can learn from the implementation experience in the area under study, acknowledge the barriers to find coping strategies and use the opportunities to support implementation.

## 1.3 Research question and aim

Based on this background and relevance, the aim of this study is to identify barriers and opportunities for the implementation of MLS towards FR in an urban context. By identifying such barriers and opportunities the research can contribute to a better understanding of the implementation process of MLS as well as the link between MLS and FR. Thereby, the research should provide insights that make it easier for urban FRM to implement MLS and shift towards FR and present an opportunity to learn from a location where the implementation of the MLS approach has been practiced already. To achieve these objectives, the thesis answers the research question and sub-questions indicated in box 1.

Box 1.

Main research question:

**What are the barriers and opportunities for the implementation of urban multi-layer safety to increase flood resilience?**

Sub-questions addressed by the theoretical framework:

| | |
|---|---|
| SQ1: | What are the concepts of multi-layer safety and flood resilience? |
| SQ2: | How does multi-layer safety contribute to flood resilience? |
| SQ3: | Which barriers for the implementation of multi-layer safety can be derived from literature? |
| SQ4: | Which opportunities for the implementation of multi-layer safety can be derived from literature? |

Sub-questions addressed by data collection:

| | |
|---|---|
| SQ3.2: | Are the identified barriers also recognized in the practice of implementing multi-layer safety? |
| SQ4.2: | Are the identified opportunities also recognized in the practice of implementing multi-layer safety? |
| SQ5: | What are additional barriers that are experienced or expected by practitioners? |
| SQ6: | What are additional opportunities that are experienced or expected by practitioners? |

*Box 1. Research questions*

## 1.4 Research design

The city of Rotterdam is selected as a case study for studying the barriers and opportunities for the implementation of MLS, as it is a delta city that is regarded a frontrunner in climate adaptation and in applying the MLS approach. The city is currently "in the second generation of climate adaptation already" (Molenaar, 2020, min. 07:26-07:33) and seen as a good example in terms of climate adaptation among which is the implementation of MLS towards FR (C40 Cities Climate Leadership Group, 2016). By carrying out the empirical investigation with a single case study focus, detailed information on the process of the implementation and the associated barriers and opportunities faced in Rotterdam can be researched. The data collection is carried out by qualitative semi-structured interviews with experts corresponding to the different layers of MLS. Due to the specific context of the study, the research builds upon the ‘good practice’ example of Rotterdam and enables a rather flexible translation of the experienced barriers and opportunities for other locations.

## 1.5 Case description

The region that is analyzed within this single case study is the Dutch city of Rotterdam (figure 1). Rotterdam has a population of about 650 thousand inhabitants (UrbiStat S.r.l., 2022) and is located in the delta ‘Rijnmond-Drechtsteden’ in the province Zuid-Holland. The delta is an area of conjuncture between riverine waters and the sea, which in combination with the low-lying land and the high level of urbanization and economic values makes the city vulnerable for flooding (Vos, et al., n.d.).

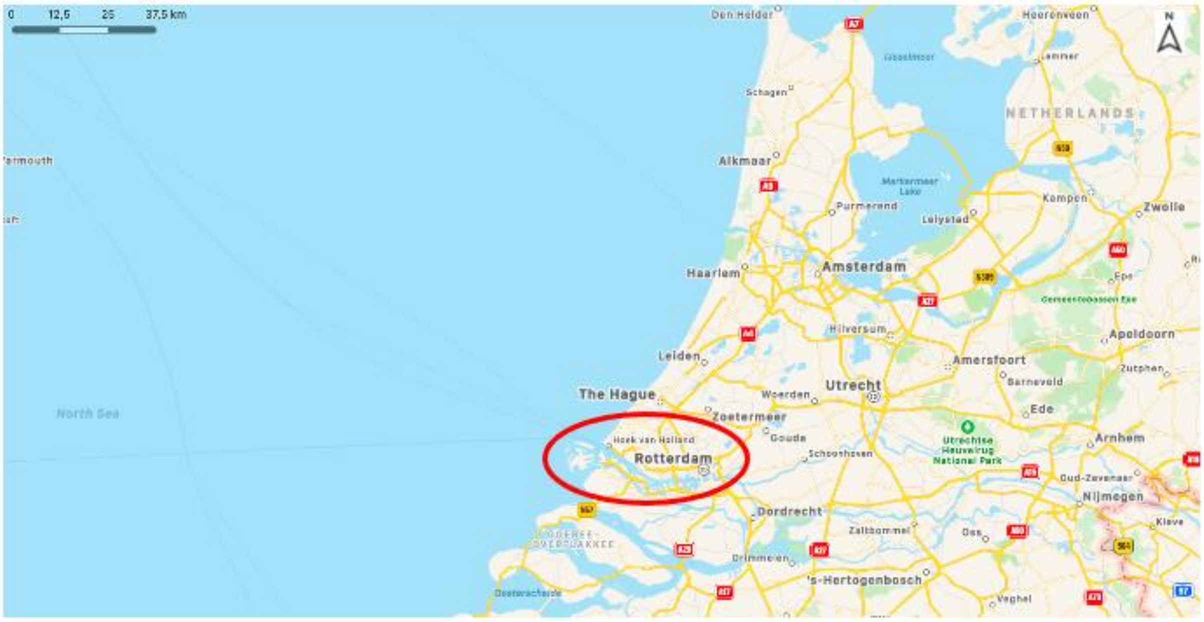


*Figure 1. Rotterdam case area (by author)*

Large parts of the city are on the altitude of mean sea level and protected by a water defense system of dikes and storm surge barriers. The port of Rotterdam as well as various forms of urban infrastructure and certain neighborhoods are also located outside this primary dike line and are therefore even more prone to flooding (Eraydin & Taşan-Kok, 2013). Climate change developments like sea level rise and extreme weather patterns are expected to considerably amplify the flood risk in the city and thereby create various water safety challenges (Eraydin & Taşan-Kok, 2013).

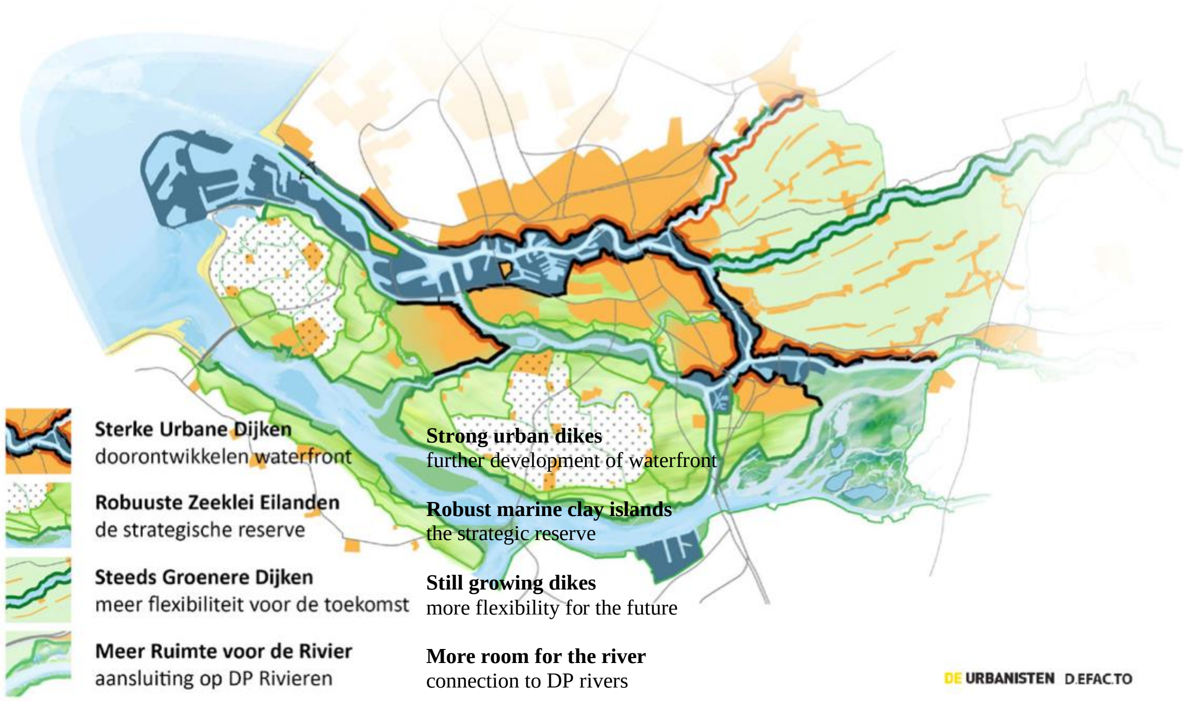


*Figure 2. Spatial strategy map Rotterdam (Vos, et al., n.d., modified by author)*

The spatial set up of the city with a focus on water is illustrated in the figure 2 above. Thus, the primary dike lines can be seen along the river delta which flows into the North Sea. The dark blue space depicts the port structures and other unembanked areas of the city outside the dikes.

## 1.6 Reading guide

Chapter two incorporates the theoretical framing of the research, introduces the conceptual model of the study, and answers the theoretical sub-questions. In the following, the methodology is covered by chapter three, whereas the results and conclusions are discussed in chapters four and five.

# 2. Theoretical Framework

In this section, the central theoretical components for this thesis are discussed. The two main concepts are FR and the MLS approach. Resilience is understood as an overarching and broad concept, which is discussed with a pointed emphasis on the issue of flooding. Before the different layers of the MLS approach are linked to a conceptualization of FR, this chapter starts off with a detailed view on the development of resilience theory (2.1) leading to the concept of FR and finishing off with a few critical points about resilience. Subsequently, the MLS approach is discussed in detail and connected to FR (2.2), before linking it to implementation theory and applying it to an implementation framework (2.3), which helps to substantiate and understand the barriers and opportunities for implementation on a local level. These barriers and opportunities are examined from a theoretical perspective (2.4-2.5) before concluding through answering the theoretical sub-questions SQ1-SQ4 (2.6). Finally, the main concepts and their interrelations are visualized in the conceptual model of this thesis (2.7).

## 2.1 Development of the resilience concept towards flood resilience

To understand how the implementation of MLS can increase FR, a deeper comprehension of the development and the different forms of resilience is necessary, as the MLS approach reflects different elements that can be referred to the evolution of resilience. Resilience is widely discussed in the spatial planning domain and many scholars “acknowledge that spatial planning plays an important role in promoting urban resilience to cope with climate change” (p. 201 (Lu & Stead, 2013)), but the term is used imprecisely in planning research (Davoudi, 2012), which involves the risk of resilience being used as a vague buzzword. To unpack the concept of resilience, the roots and development of resilience theory are explored, and the resulting different forms of resilience discussed. Thereby the relevance of resilience theory for spatial planning becomes apparent, before further specification leads on to the flood management domain and discusses FR. Concluding, a few critical aspects about FR and the translation of resilience to social sciences are discussed.

### 2.1.1 Engineering and ecological resilience

The term resilience is originally attributable to physics and refers to “characteristics of a spring and describe the stability of materials and their resistance to external shocks” (p.300 (Davoudi, 2012)). Ensuing, resilience was introduced to the field of ecology and can be classified into a period in the 1960s and 70s, where natural systems were increasingly recognized as dynamic and unpredictable in contrast to prevalent linear thinking (de Bruijne, et al., 2010). In the following the author frequently refers to ‘systems’. This term should be understood as an overarching expression for different kinds of systems, like ecosystems, climatic systems, social systems, etc., or combinations like socio-ecological systems.

The earliest understanding of resilience is mostly referred to as 'engineering resilience' and describes a system's ability to withstand a shock and return ('bounce-back') to the condition prior to the event that caused disturbances (Davoudi, 2012; Martin-Breen & Anderies, 2011). A central element of the different forms of resilience is the reference to an equilibrium. Engineering resilience assumes one balanced condition i.e., the equilibrium, to which a system returns or which a system maintains. Therefore, the level of resilience is directly linked to the stability to resist stress and the time to regain the prior equilibrium (Davoudi, 2012).

The proximate form of resilience is mostly referred to as 'ecological resilience'. Inherent to this form is the assumption that the state of a system can change fundamentally. Therefore, from that perspective resilience not only involves withstanding stress events, but especially also the ability to adapt to a completely new situation. This shows the main differentiation to engineering resilience, as it implies that there is more than one equilibrium (Davoudi, 2012). When acknowledging that systems can change the so-called regimes, i.e. fundamental conditions of a system, in which new equilibria can be reached, the actual moment of transition between the different regimes becomes a focal point (de Bruijne, et al., 2010). In contrast to engineering resilience and the idea about bouncing back to the prevalent equilibrium, ecological resilience implies bouncing forward to a new equilibrium (Davoudi, 2012). If bouncing forwards or backwards, both forms assume that breaking away from the equilibrium is directly linked to a cause like a crisis or shock event.

Even though the ensuing forms of resilience leave the idea of an equilibrium behind, the issue of regimes and regime changes is helpful for understanding the implementation of MLS. In this regard, two regime changes seem to be especially relevant. On the one hand, a change in the climate regime that will change weather patterns and water levels in the long-term and creates fundamentally different environmental circumstances regarding flood risk. On the other hand, a change in water management and governance from a "prediction & control regime" to an "adaptive & integrated regime" (p. 573 (Pahl-Wostl, et al., 2010)).

### 2.1.2 Evolutionary resilience

The third form of resilience is the 'evolutionary resilience', which states a paradigm shift, because it follows a different fundamental premise. Contrary to engineering and ecological resilience, this approach steps away from the idea of an equilibrium and direct causalities (Davoudi, 2012). According to that, systems are always in flux and change continuously with no predictable cause and effect correlation, which implies the requirement for the ability of flexible and adaptive guidance by planners acting in such systems. Originating from complexity theory, the description of for instance cities as complex adaptive systems (CAS) entails the assumption of interactions between many diverse actors in a dynamic and non-linear manner and attributes adaptive capacity, i.e. the ability to change their fundamental structure incrementally or as a response to stress factors (Martin-Breen & Anderies, 2011).

Regarding this research, it is important to be aware of the context of a complex adaptive system in which the MLS approach is fostered by opportunities or hindered by barriers, because it provides a basic understanding of how an urban system operates and changes. To continue the specification and give more context to these rather broad categorizations, the following chapter discusses resilience in the field of spatial planning.

### 2.1.3 Resilience and spatial planning

To understand how cities like Rotterdam, as complex adaptive systems, develop over time, the adaptive cycle model originally by C. S. Holling is a popular perspective taken by spatial planning scholars and refers to the form of evolutionary resilience (Lu & Stead, 2013). The Figure 3 illustrates this cycle. It includes four phases that represent an ongoing process of how systems change.

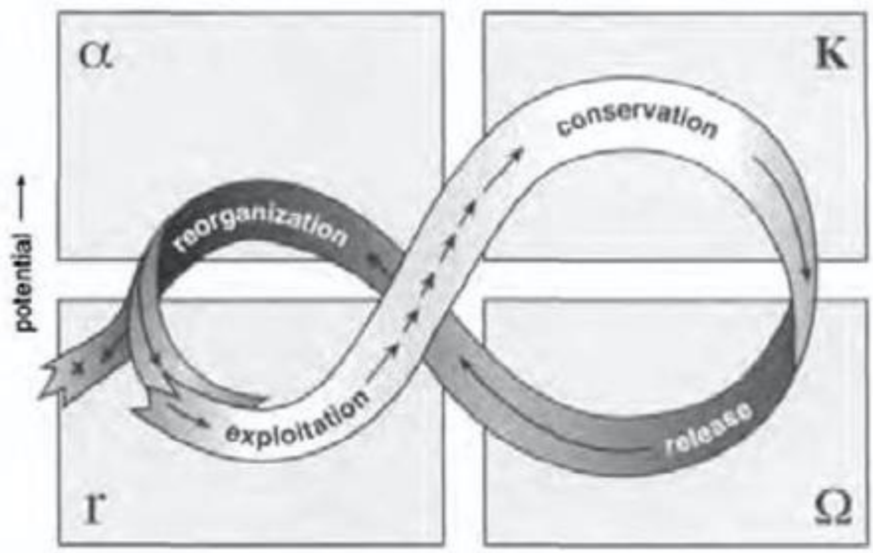


*Figure 3. Adaptive Cycle (p. 34, Figure 2-1. (Holling & Gunderson, 2002))*

The exploitation phase (r) relates to a slow consolidation of the current functions and structure of a system. Following on the conservation phase (K), that is characterized by a stagnation of growth and system stabilization, the release phase (Ω) incorporates the swift disruption of the systems structure and functions, from which the process transitions to the reorganization phase (α). This phase is characterized by innovation and formation of new structures and functions, before moving swiftly to the exploitation phase again (Holling & Gunderson, 2002).

Davoudi (2012) makes a particular connection between the release phase, especially at the state of transforming towards the reorganization phase, and fundamental notions of planning with "the capacity to imagine alternative futures" (p. 303) and transformative preparedness. Also, in the light of growing challenges and risks due to the climate crisis and socio-economic developments, the release phase appears pivotal, as the vulnerability for sudden shocks and the inevitability of slower changes increases simultaneously. It supports the general relevance of resilience thinking for spatial planning (Eraydin & Taşan-Kok, 2013) and implies possible windows of opportunity related to flooding events following on the disruption of a systems structure and function. Therefore, acknowledging the adaptive cycle and linking it to the implementation of MLS, urges planners to anticipate the steadily changing process and the significance of the transition from release to reorganization. The adaptive cycle can thereby help to position the current flood management system and enable a deduction of circumstances for the implementation of a new concept like MLS.

To further depict how the different resilience forms affect planner's behavior, the following table 1, based on White and O'Hare (2014), shows different planning approaches for the two interpretations of resilience. They merge engineering and ecological resilience and contrast it with evolutionary resilience. By identifying these different approaches, it becomes obvious that the planner's role changes significantly throughout this shift.

*Table 1. Planning approaches for different forms of resilience (modified by author, based on (White & O'Hare, 2014))*

| Engineering/ecological resilience | Evolutionary resilience |
|---|---|
| techno rational | sociocultural |
| vertical integration | horizontal integration |
| building focus | societal focus |
| homogeneity | heterogeneity |

To understand the opportunities and barriers for the implementation of MLS towards resilience it is relevant to be aware of the different ways of acting that can cause challenges or create possibilities for mutual supplementation. The following subsection shows that this dichotomy is also present in the flood management domain.

### 2.1.4 Flood resilience

This paradigm shift is also recognizable in the flood management realm and is extensively discussed with a focus on the Dutch water sector as a response to the uncertainties about climate change related hydrological hazards. What is often referred to as a water management transition, describes a change of how flood risk is perceived and how to act on it. The approaches shift from a linear predict-and-control paradigm that utilizes technical flood defense measures to keep water out, towards a holistic and integrated paradigm that is characterized by a diversification of FRM measures and the capacity to adapt to uncertain developments and flooding events (Ritzema & Van Loon Steensma, 2018; Restemeyer, et al., 2015).

However, it is still controversial what FR really entails. There is a debate about the compatibility of the idea of resistance in terms of flood defense measures within the FR concept (McClymont, et al., 2020). Referring to the preceding description of the paradigm shift in resilience thinking, spatial planning, and flood management alike, the concept can convey a clear separation and therefore an either-or consideration. Now, is FR then undermined or contrary to resistance or can it also be a supplement? Some scholars represent the idea that resistance opposes and hinders FR, as flood defense measures like dikes and storm surge barriers disturb aquatic and coastal ecosystems and alter the geomorphological conditions of water bodies and the adjacent areas (Douven, et al., 2012), which adds an ecosystem-based perspective that is being associated with FR. Furthermore, flood defense measures can lead to a high exposure of the protected areas behind flood defense infrastructure in case the defense system fails, especially looking at overtopping or breaches in the long-term (Liao, 2014).

Others see resistance as one element of FR and discuss this dichotomy as inappropriate. According to that, FR is understood as a fusion of both. 'Engineering resilience' in the form of technical flood protection that reduces the probability of flooding, and 'evolutionary resilience' in the form of a diversification of measures that focus on socio-ecological nexuses to foster the capacity to adapt and to transform (Restemeyer, et al., 2015; Karrasch, et al., 2021).

What is also worth a remark is, that the term FR is far from only being associated with evolutionary resilience. In fact, a study by Rodina L. shows that 45.6 percent of the analyzed articles about FR from the water management domain, refer to the 'old' notion of engineering resilience (Rodina, 2019).

Thus, for further engagement with FR, it is helpful to clarify how it can be conceptualized and thereby how it is understood in the context of this study. Due to the consideration of the different forms of resilience and a consensus with the different layers of the MLS approach, the conceptualization in this study follows the approach also used by Restemeyer et al. (2015). Accordingly, FR builds on a threefold combination of "robustness, adaptability and transformability" (p. 46 (Restemeyer, et al., 2015)). Putting these terms in direct relation to flood management, the first two notions reflect the commonly used risk equation of risk = probability x consequences. Robustness is meant to lower the probability of a severe flooding event, while adaptability should reduce consequences for the floodplain in case of flooding, which can be achieved through physical and organization measures. Transformability addresses mainly the issues of societal change and awareness, and the interdisciplinary and intersectoral integration (Restemeyer, et al., 2015).

With these three properties, FR merges all three of the previously discussed forms of resilience into one concept, that provides the normative goal of holistic FRM. The theoretical foundation and conceptualization of FR clarify what MLS is supposed to achieve. Thus, in the context of this thesis, the conceptualization of FR is relevant groundwork to research the opportunities and barriers for the implementation of MLS.

### 2.1.5 Critical perspective on (flood) resilience

Adding on to this elaboration of the development of resilience and FR, the concepts are thoroughly debated in academia and cover some aspects that address challenges and critical points about such. The main criticism aims at varying interpretations of what resilience precisely means. As mentioned before, resilience is referred to in multiple disciplines sometimes following the 'engineering' version and sometimes the 'evolutionary' version, which are fundamentally different and indicate fundamentally different approaches for planners (Laeni, et al., 2019). This is countered in this study by the previously mentioned conceptualization of FR.

Furthermore, Laeni et al. (2019) analyzed related literature and identified points of criticism with a focus on policy adoption of the resilience concept. The first one applies to the operationalization, i.e. the translation to practice, of the concept (Laeni, et al., 2019). To address this challenge, the MLS approach is discussed in detail in the next chapter as a possibility for a more operational step towards FR.

Another point of criticism is the danger of passing on safety responsibilities from governmental actors to the citizens and leaving questions of "Resilience by whom? Who gets to decide" (p.158 (Laeni, et al., 2019)), potentially abandoning parts of the society. Davoudi sees this risk as a particular problem within the translation of the concept from the natural sciences to the social realm. Thus, the operationalization runs risk of turning to "self-reliance" (p. 305 (Davoudi, 2012)) and passing on responsibilities. However, this critique goes beyond the scope of this thesis as the process of implementing MLS is observed regarding the roles of governmental and private actors while not going into detail with the individual role of citizens.

### 2.1.6 Implications

The discussion of the development of the resilience concept and the conceptualization of FR now provides important groundwork to clarify what MLS is operationalizing throughout the implementation process and to understand the broad theoretical context in which the MLS approach is positioned. Also, the formulation of the normative goal for MLS is essential to eventually identify and analyze the barriers and opportunities. The following explores MLS and discloses the interrelations between the different layers and the conceptualization of FR.

## 2.2 The multi-layer safety approach

The multi-layer safety approach, or also multi-layered safety, is a concept that addresses flood risk and was first taken up to policy in the Dutch National Water Plan in 2009 (Hoss, et al., 2013). In contrast to generally more established approaches of probability reduction in flood management, MLS takes a risk-based approach following the formular of 'risk = probability * consequences' and thereby also addresses the situation of a flood reaching vulnerable areas and adverse consequences of such events (Hoss, et al., 2013). By taking such possible scenarios and uncertainties into account, the approach incorporates the opportunity of increasing adaptive capacity, extending the toolbox of flood management measures, and achieving more integrated flood safety.

### 2.2.1 What MLS is about

The approach originally comprises of three interrelated layers: The first layer is about protection and is associated with the reduction of probability of flooding incidents. It incorporates for example traditional measures like dikes and storm surge barriers. This refers to the prevalent and especially in the Netherlands historically manifested way of protecting cities and land from inundation.

The second layer is commonly tied to terms like spatial planning, spatial adaptation, or prevention. Regarding this layer, the focus lays on how the space behind the first layer measure, or in a flood-prone area without flood defenses, is set up for the situation of a flood occurring. It is commonly linked to failure of first line protection systems like a dike breach but is basically tantamount for a possible flooding scenario in areas with limited or no primary flood protection. Inherent to this second layer is the consideration of the possibility of a flood reaching and threatening people, livestock, infrastructure, or other assets and thereby aims at reducing the consequences of a flooding incident.

In contrast to the first two layers being predominantly concerned with physical measures, the third layer is in its core organizational and communicative and mostly described as emergency response and planning, crisis management or disaster management. This includes measures like evacuations, the organization of emergency services, and risk communication (Kaufmann, et al., 2016; Hoss, et al., 2013; Leskens, et al., 2013; van Herk, et al., 2014; Gersonius, et al., 2011).

Recently, a fourth layer is added to the concept, which is resilient recovery. It aims at the restoration after a flooding event, that can include transformational processes as a response to a disaster and measures to regain habitability (Karrasch, et al., 2021; Interreg North Sea Region FRAMES, n.d.).

The table 2 shows a collection of measures from different studies and represents an overview of the measures that are associated with the different layers of MLS. The table does not represent a fully comprehensive, but rather an extensive compilation of measures.

*Table 2. Collection of MLS measures (by author, based on (Hoss, et al., 2013; de Moel, et al., 2014; Karrasch, et al., 2021))*

| Layer 1 Prevention/Protection | Layer 2 Spatial adaptation | Layer 3 Emergency management | (Layer 4) Resilient Recovery |
|---|---|---|---|
| structural flood defenses (dikes, barriers, etc.) | reconsidering of settlements | organized evacuation | clean-up, reconstruction, and recovery |
| non-structural flood defenses (e.g., eco-engineering) | compartmentalization (zoning) | temporary flood defenses | reprocessing/learning processes |
| flood defenses allowing overflow | elevating areas | temporary flood-proofing of buildings | flood insurance and compensation |
| redistributing discharge | elevating buildings | self-reliance | |
| retain run-off | elevating infrastructure | emergency relief | |
| extending room for waterways | dry proofing | warning systems | |
| | wet proofing | emergency communication | |
| | removal/relocation | flood forecasting | |
| | flood retention basins | | |
| | green infrastructure for infiltration | | |

Based on insights from literature (Hoss, et al., 2013; de Moel, et al., 2014), it is relevant to differ between MLS in embanked and unembanked areas, because the starting point and context in which the approach is implemented shapes the feasibility. This reason becomes apparent and is discussed during the following two sub-sections.

### 2.2.2 MLS in embanked areas

Research about MLS that is regularly referred to is a pilot case study of the Dutch city of Dordrecht, regarding the implementation of MLS measures. This study by Hoss, Jonkman and Maaskant (2013), takes a focus on the possible combinations of different MLS measures spanning across the three layers and its interrelations and elaborates on the issues of bankability and cost-efficiency of alternatives and supplements to flood protection structures in the form of the MLS approach. The conclusion for the city of Dordrecht is that flood management becomes more complex when the number of applied measures increases due to the higher number of involved stakeholders and need for coordination. Secondly, the effective combination depends on individual characteristics of the area at hand. Furthermore, the implementation of MLS seems to be less cost-efficient the better one of the layers is equipped already (Hoss, et al., 2013). For the Netherlands this seems to be the case with its institutionally rooted flood defense system, which is why in their study the MLS approach, respectively the diversification towards layer two and three, is ascribed only an additional role for the inner dike areas of the country (Hoss, et al., 2013).

This comparatively well-protected Dutch situation with mostly layer one measures also becomes interesting beyond a cost-benefit perspective, because the continuous reinforcement of flood protection structures not only seems to reduce the necessity of additional diverse measures, but also potentially reduces the awareness of the population for the possibility of a flooding scenario and thereby increases the vulnerability of the inner dike areas (Haer, et al., 2020; Stevens, et al., 2010).

This issue is broadly discussed as the so called 'levee effect' or 'safe development paradox'. Accordingly, the high level of protection conveys and to a certain degree assures flood safety, which increases development, economic investments, and the number of inhabitants in the diked areas that rely on these structures and consequently individual or community awareness of and preparedness for flooding diminishes (Haer, et al., 2020). These strains of theory then prompt the question what is included in the calculations for cost-efficiency of the implementation of MLS measures. The associated adverse monetary and social consequences that a flooding scenario could have on inner dike areas usually seem not to be included.

The 'levee effect' also affects the third layer for embanked areas. Emergency response becomes almost exclusively relevant for flooding scenarios due to dike breaches. Leskens et al. (2013) for example create inundation models based on such scenarios for the West-Friesland to visualize the consequences and stimulate the development of MLS measures during a workshop. They conclude that efforts to reduce consequences while maintaining flood protection is difficult to understand for the participants (Leskens, et al., 2013), which is a contrary understanding to MLS and FR.

### 2.2.3 MLS in unembanked areas

Contrary to areas that are positioned inside a dike ring, a different picture appears in unembanked areas, as it is also implied by Hoss et al. (2013), when referring to the special characteristics of the regions under consideration. De Moel et al. (2014) take a focus on layer two measures for such unembanked areas in the city of Rotterdam. They offer arguments for spatial adaptation measures that could reduce consequences of a possible flooding scenario partly drastically for the researched unembanked areas. Though, what should be kept in mind is that such calculations can vary a lot regarding the actual measure or combination of measures chosen and the climate change scenarios referred to, which can relativize assumptions and is also mentioned by the authors (de Moel, et al., 2014). Despite such unclarities and uncertainties, some arguments for the implementation of layer two measures, especially for unembanked areas, come up. These are: the higher probability of flooding and therefore more evident impact of adaptation; the generally "lower inundation depth" (p. 897) compared to for example poldered regions behind the dike; comparable good predictability of flooding as it is not attributed to structural collapse of flood defenses; economic incentive for unobstructed riverside or shore properties; and especially for the Netherlands the pressure to reduce possible damage, because of the rejection of responsibilities for flood related issues by the state when it comes to the unembanked areas (de Moel, et al., 2014).

For unembanked areas, layer three seems to be intertwined with layer two. Thus, emergency response is understood as a combination of emergency/disaster planning prior to a flooding event, which involves setting up scenario-related contingency plans and the operational management during a flooding event, which contains the ability to carry out necessary operations (Karrasch, et al., 2021).

### 2.2.4 Integration of the layers

Regarding the implementation of the MLS approach, the integration of the layers reflects a vital element. Bosoni et al. (2021) refer to 'policy integration' as "combining the policy goals of the water domain, spatial planning domain, and disaster management domain" (p. 2) and 'territorial integration' in the form of "cross-boundary working that encompasses policy coherence across spatial scales namely national, regional, and local" (p. 2). The data collection of this study explores the horizontal and vertical integration, i.e. the integration across the levels of authority, as well as the responsibilities and perspectives of the different layers of MLS.

### 2.2.5 Linking MLS and flood resilience

After having discussed the MLS approach and the concept of FR, various linkages between the layers of MLS and the conceptualization of FR show how MLS comprises an operationalization of the broader components of FR. Linear thinking and a command-and-control concept characterized by technical solutions relates mostly to the engineering form of resilience and the FR component of robustness, which finds a practical counterpart in structural flood protection as the first layer of MLS.

The component of adaptability as part of FR is operationalized through the second layer of MLS (Karrasch, et al., 2021). The spatial setup of cites is central to how the area can adapt to flood risk and to reduce the consequences of flooding incidents. In the context of adverse impact reduction, also the third layer of MLS, emergency response, comes partly into play when looking at the adaptability component of FR. Organizational preparedness and risk communication can be seen as non-structural elements of this operationalization.

Additionally, the third layer of MLS can also partly contribute to the third component of FR, transformability. As the immediate reaction of how a flooding event is approached in terms of organizational prioritization, groundwork for transformation can start already here. The layer which refers more clearly to transformability is the recently added fourth layer of resilient recovery, as it focuses on how a flooding event is processed and the lessons learned.

This implies that a vital component for the evolutionary resilience elements of FR is not part of the initial form of how MLS is included in Dutch policy. In line with that, the risk approach, that is elementary for MLS, is criticized for focusing on conserving the status quo and lacking the transformation claim that is inherent to evolutionary resilience (Fünfgeld & McEvoy, 2012) as well as to the conceptualization of FR used in this thesis, which could create shortcomings of the operationalization regarding the normative goal.

In conclusion, there is much potential to increase FR by implementing the MLS approach due to the diverse and integrated approach of combining various measures that in synergy can reduce flood risk. Though the realization of this synergy remains a challenge and demands integration of the individual components to implement MLS and effectively increase FR.

## 2.3 Implementation theory

This section adds implementation theory to the discussion of the resilience concept and the positioning of the MLS approach. It introduces an implementation framework to enable an in-depth analysis of the implementation process of MLS.

Khan and Khandaker (2016) describe policy implementation as the translation of broad visions and goals to an operational level of implementing the policy content through specific action. A socially relevant problem or challenge underlies the initiated implementation through "governmental interventions" (p. 539 (Khan & Khandaker, 2016)). The increasing flood risk due to the changing climate and socio-economic developments constitutes such a societal challenge. The normative goal of FR in line with a more specific theoretical approach like MLS represents the vision or principal formulation of how the challenge should be addressed.

An established form of conceptualizing theories and research in policy implementation -and implementation sciences in general, is the creation of implementation frameworks (Ogden & Fixsen, 2014). As frameworks run risk of illustrating processes as linear and controlled, it is noteworthy that implementation is regarded as an ongoing process of various preparatory and revising steps (Ogden & Fixsen, 2014) and is subject to fuzzy, political and non-linear decision making processes, in line with the assumption of 'bounded rationality' that softens the idea and rigidity of completely rational choices (Simon, 1990).

For this study, the 'Consolidated Framework for Implementation Research (CFIR)' by Damschroder et al. (2009) is used. The CFIR is a framework that is based on a consolidation of multi-disciplinary implementation constructs, definitions, and terms, which was developed within the medical and health service research domain (CFIR Research Team-Center for Clinical Management, 2021). The CFIR framework is used for this study for the following reasons.

First, the comprehensive nature of the framework consolidates knowledge and experiences gained through various implementation studies and thereby incorporates and combines many other frameworks and theories (Damschroder, et al., 2009). Secondly, the framework reflects on different levels and intertwining layers, which is essential for the integration of the layers in MLS. Thirdly, the focus on the contexts of an implementation process is a central component in the framework, which is helpful to understand and classify the circumstances for the local implementation within this single case study about Rotterdam. This contextual focus blends in with the understanding of evolutionary resilience of constant non-linear interchange within systems. Lastly, the reference to a framework from the medical context and application to the flood management context is no novelty, as for example also Hoss et al. (2013) adapt a framework of medical strategies to their purpose of analyzing the MLS approach in Dordrecht.

In the figure 4 below the five main elements of the implementation framework by Damschroder et al. (2009) are illustrated and should be perceived as interacting with each other in complex ways. The processes throughout develop in a non-linear way and are affected by continuous feedbacks and bounded rationality. These main elements are referred to the circumstances of implementing MLS in the following.

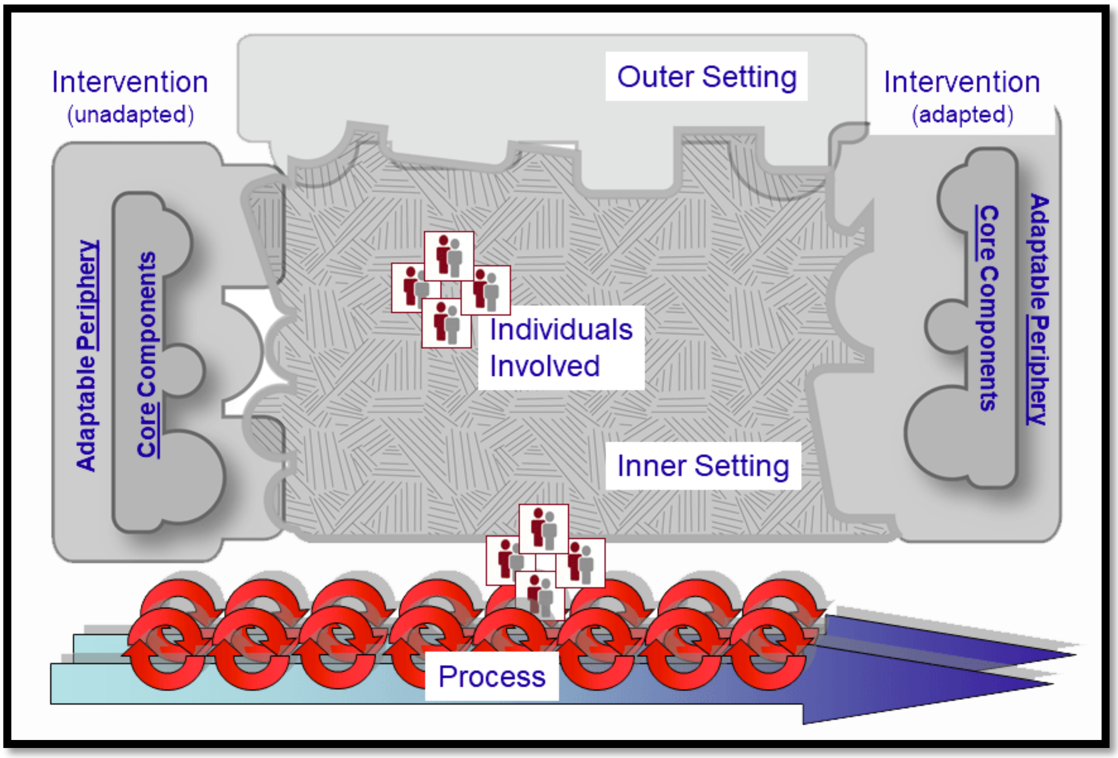


*Figure 4. CFIR (CFIR Research Team-Center for Clinical Management, 2021)*

The first element is the intervention that is implemented to practice. In the case of this study the intervention happens on the meso-level in form of the MLS approach as a policy concept in Rotterdam. In the framework, the intervention is subdivided into two elements and is characterized as initially not fitting to the context of implementation and therefore needs adaptation along the process of implementation. The elements of the intervention that entail essential features and cannot be adapted or changed are referred to as “core components” (p. 3 (Damschroder, et al., 2009)) and the elements that are more flexible are referred to as the “adaptable periphery” (p.3 (ibid.). Applying these characteristics to the MLS approach on a meso-level, the involvement of all layers and the integration of these layers are understood as the ‘core components’, whose implementation is performed through specific measures on the micro-level. The ‘adaptable periphery’ is seen in the distribution of responsibilities and the prioritization among the layers, which can be adapted to the circumstances.

The “inner and outer setting” (p. 5 (ibid.) are the next two relevant elements along the implementation process that can become indistinct and are not always clear to differentiate. Damschroder et al. (2009) describe that “the outer setting includes the economic, political, and social context” (p. 5) while the “inner setting includes features of structural, political, and cultural contexts” (p. 5). When put in relation with the MLS approach, the ‘outer setting’ seems to be shaped by among others financial schemes and budgets, national and international politics, media coverage, societal values and mindsets, and issues like the society’s demand for safety and social compatibility between FRM and other issues. The ‘inner setting’ is rather understood as covering the contemporary flood management system and institutions, the added sectors such as urban/spatial planning and disaster management that are to be involved in the new approach to flood risk, as well as the regional and local political setting and power relations.

By applying the CFIR to MLS, the intertwining of these contexts becomes apparent and emphasizes the complexity inherent to the implementation process. Thus, MLS implementation along with its barriers and opportunities involves various actors within external and internal settings, spanning across various levels and disciplines, which makes the implementation a messy matter, that is determined by power structures, partisan politics, knowledge imbalances, and competing objectives.

The next element of the CFIR is the “individuals” (p. 5 (ibid.) that are concerned with and participating in the process of implementation and brings in another source of uncertainty adding on to the chaotic process. The ‘individuals’ have a special role to play and simultaneously complicate the process, as they are a self-organizing and unpredictable element with diverse “mindsets, norms, interests, and affiliations” (p. 5 (ibid.), and they have the possibility to advocate and make decisions (Damschroder, et al., 2009). Therefore, especially ‘individuals’ can foster or hinder the implementation process. Regarding the MLS approach, this element of the CFIR is about the professionals of the governmental and private sectors involved in the different layers, possible boundary spanners or change agents, and citizens.

Lastly, the “implementation process” (p. 5 (ibid.)) is a vital element of the framework. It reflects the ongoing order of interrelations, feedbacks, and dynamic processes between all the elements discussed before, towards a successful implementation and an adapted intervention that fits the context (Damschroder, et al., 2009). These processes do not happen in an orderly sequence, but rather “simultaneously and at multiple levels” (p. 5 (ibid.)), which makes the implementation process a chaotic back and forth at times with no universally clear procedures and therefore does not build on a predictable and employable cause and effect relationship. Instead, these processes demand flexibility and the ability of continuous adaptation to the changing circumstances of the individuals involved in the process.

All of this implies that the implementation of such an integrated and comprehensive approach like MLS is not easily realized. The approach itself includes a variety of actors and sectors on different layers of authority, while the process of implementing MLS underlines these challenges. Therefore, it is important to know when and how the implementation can be successful, hence, to identify the barriers and opportunities that need to be overcome or can be utilized.

## 2.4 Barriers for multi-layer safety implementation

Regarding the implementation process of IFRM approaches like MLS, a few barriers are identified in water management literature that can hinder a development towards resilience. A recent study by (Mercado, et al., 2020) relates to the implementation of MLS, as the authors concerned themselves with barriers that are faced in the urban case region of Manila in the Philippines regarding the concept of IFRM, which has several similarities and overlap with the MLS approach and can both be regarded components of the overarching paradigm shift in flood management as related to the discussion in the prior chapter 2.1.4. They identified a dozen barriers, but also emphasize the difference of the Philippines as a developing country facing more barriers than developed countries (Mercado, et al., 2020). Nevertheless, a number of these barriers especially regarding governance can also be found in developed countries and are therefore relevant for the case region of Rotterdam in the Netherlands. The first three "Lack of a sole organizing body; Lack of communication; Lack of funding" (p. 5 (Mercado, et al., 2020)) can be related to the particular focus on European countries, which is given by Mercado et al. (2020) as an entrance point to the challenges of the implementation of IFRM, in which they cover the issues "cultural and economic tensions; technical lock-in in prevailing structural measures; political oppositions; weak enforcement and low compliance of building restrictions; fragmented governance structure for flood management" (p. 2 (ibid.)). Thus, the results of this study can also be valuable for this thesis, not the least because of these similarities, but also because of the shift from a linear predict-and-control paradigm towards an integrated and holistic approach to flood risk in fact being regarded a global phenomenon (ibid.).

Mostly compliant with these observations and with some supplements, a few main challenges are discussed in literature that address not only the implementation of IFRM approaches, but also seize barriers that occur when transitioning from an engineering resilience perspective on flooding towards a more complex evolutionary resilience perspective, to refer to the terminology of section 2.1. To get an overview of the identified barriers and their interrelations, the following figure 5 illustrates these prior to further discussion in the text.

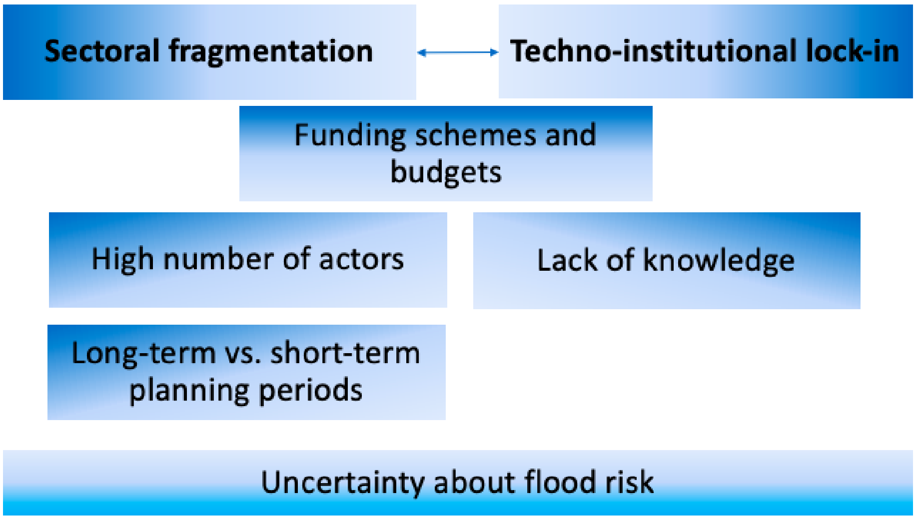


*Figure 5. Barriers for MLS implementation (by author)*

### 2.5.1 Overarching barrier I: Sectoral fragmentation

The first overarching barrier is summarized as **sectoral fragmentation**. In figure 5 this barrier is illustrated as one of two overarching barriers, that is understood to be also interrelated with a techno-institutional lock-in as the second overarching barrier, which will be discussed in the following section. These two are linked to the other associated barriers below.

As discussed before, MLS incorporates layers of responsibility for a variety of fields of duty, that are covered by various sectors like water management, spatial planning, and disaster management, and actors spanning across different private and public scopes. Referring to academia, this fragmentation arises from and is expressed in challenges of divergent or contrary prioritization and objectives of the sectors (van Herk, et al., 2014; van Herk, et al., 2011), which potentially leads to conflicting positions. Especially when rather novel parties in the flood management realm from spatial planning or disaster management come to interact with long established actors in water management, conflicts may arise about the interpretational sovereignty of flooding issues (Hegger, et al., 2014). In line with this fragmentation, the governance of MLS implementation and the application of IFRM in general is perceived as a challenge, according to Hartmann and Driessen (2017) especially with a focus on the responsible actors for the first two layers of MLS, being water managers and spatial planners (Hartmann & Driessen, 2017). This is because these two domains are characterized by different modes of governance resulting from differences in the relations within their area of expertise, the institutional context, and from which perspective issues are approached (Hartmann & Driessen, 2017). Due to these barriers, it is suggested that novel or altered forms of governance are necessary, that combine both worlds (Hartmann & Driessen, 2017; Hegger, et al., 2014), like a "spatial water governance" (p. 145 (Hartmann & Driessen, 2017)). Referring to the CFIR, this barrier seems to be positioned in the 'inner setting', as the fragmented sectors are all to be directly involved with the implementation process of MLS.

### 2.5.2 Overarching barrier II: Techno-institutional lock-in

The second overarching barrier is referred to as a **lock-in** situation of the protection paradigm and is mostly discussed in terms of a technical or technological- and institutional lock-in. This lock-in and sectoral fragmentation seem to partly reinforce each other, because a lock-in can prevent integration of addressing FRM across other sectors and keeps the involvement within the sector(s) that mostly focus on engineering flood protection, while sectoral fragmentation again hampers this integration.

A lock-in is commonly described as path dependency resulting from decisions that manifest due to positive feedback loops which create inertia for alternatives and make it more difficult to escape the path with every new investment (Unruh, 2000). The technical lock-in in flood management exists in protective, structural measures that reduce flood probability and create a level of perceived safety that hampers reasoning for alternatives and causes further investments in maintenance and reinforcement of these structures (van Herk, et al., 2015; Wesselink, et al., 2015). Such dike reinforcement leads to an upscaling of the flood protection system and in consequence increases the value and number of people behind the dike, which clearly refers to the prior discussed issue of the 'levee effect' (section 2.2.2).

The institutional lock-in refers to the paradigm of engineering-based flood protection being anchored in the institutional context. This is due to the historically grown culture around dikes including responsible organizations, rules and regulations, and the way of thinking (Hartmann & Driessen, 2017). Research about the MLS approach in the Netherlands and the Belgium region Flanders by Kaufmann et al. (2016), also offers a perspective on the lock-in of flood risk institutions. They take a focus on the institutionalized discourse in relation to the emergence of MLS (Kaufmann, et al., 2016). According to that, the institutionally rooted technical flood protection paradigm causes conflicts regarding the adjustment to more integrated flood management approaches. A shift in discourse and openness to adopt new ways of interacting and acting about flood risk, thus faces more challenges in the Netherlands than in Belgium (Kaufmann, et al., 2016), due to the more institutionalized protection paradigm.

Also concerning Wiering and Winnubst (2017), the Dutch flood approach is essentially locked in a web of legal standards and professional norms that determine the decision-making processes on behalf of the prevalent approach (Wiering & Winnbust, 2017). What is also remarked by de Moel et al. (2014) concerning layer two measures and relates to institutional barriers, is the lack of legal possibilities for the municipalities to impose spatial adaptation of buildings on the private developers, because they cannot demand measures that go beyond standards that are established on the national level (de Moel, et al., 2014).

In correspondence with the CFIR, the institutional part of the lock-in barrier can be positioned in the ‘outer setting’ due to the prevalent regulations and norms on a national level as well as a paradigm of protection that reaches even beyond Dutch borders. The informal culture of how flooding is perceived and approached as well as the structural elements, referring to the technical lock-in, are positioned in the ‘inner setting’.

### 2.5.3 Associated barriers

When searching for barriers that hamper the implementation of IFRM approaches like MLS, these two overarching issues of sectoral fragmentation and techno-institutional lock-in seem to cover associated barriers in a way that these are more specific barriers that contribute to the phenomena of the two overarching ones.

Accordingly, the first of these associated barriers refers to differences in **funding schemes and budgets** when looking at the distribution between the different layers of MLS (van Herk, et al., 2014; Hegger, et al., 2014). This refers to sectoral fragmentation, in a way that budgets are fragmented with their sectors alike and to the techno-institutional lock-in expressed in nationally provided annual budget for only layer 1. This barrier is to a large part positioned in the ‘inner setting’, but also linked elements in the ‘outer setting’ that include national budgets.

The following two barriers are associated to sectoral fragmentation and seem to evolve from the ‘inner setting’ as they cover the actors and sectors that are directly involved with the implementation on a local level. Firstly, the **high number of actors** and stakeholders that need to be aligned and cooperate for the implementation of MLS (Hegger, et al., 2014). Secondly, temporal conflicts are described in literature in the form of **long-term vs. short-term planning periods**, that can be related to fundamentally different interests like long-term safety or short-term economic gains, but also due to simply different planning horizons that are regarded between the different layers (van Herk, et al., 2011; van Herk, 2014).

The barrier of a **lack of knowledge** is associated to the lock-in. It can be found in literature, that there is a possible lack of expertise, knowledge, and experience for or from alternative flood management strategies besides protective measures (van Herk, et al., 2011; van Herk, et al., 2015; de Moel, et al., 2014). Referring to the lock-in it implies that the competencies are mostly increased and developed for the prevalent technical system, which prompts neglect for other domains like spatial adaptation or disaster management. Like the previous barrier, the experienced effects are expected in the ‘inner setting’, while the causes can be possibly found in the ‘outer setting’ within more general governance structures.

Finally, natural **uncertainties about flood risk** like sea level rise and extreme weather events (van Herk, et al., 2011) are especially relevant for FRM. That these issues will increase and cause growing risks is widely acknowledged, but the predicted numbers and expected local impacts vary a lot and cannot promise certainties. As this is a global issue and directly related to the climate crisis, this barrier is positioned in the ‘outer setting’.

## 2.5 Opportunities for multi-layer safety implementation

Following on the discussion of barriers, several opportunities can be identified in previous research about integrated flood risk management (IFRM) approaches like MLS, that have been experienced or are expected for the implementation process.

A formal opportunity is seen in **supranational governance pressures** and can be found in the prior mentioned EU Floods Directive, that initiates and demands a turn to broaden the perspective on FRM including the consideration of consequence-reducing measures and an integration of different sectors (Bosoni, et al., 2021). This opportunity can be positioned in the ‘outer setting’ of the CFIR as it covers the influence of a supranational organization. Even though such a directive does not directly influence implementation on the local level, it sets a pattern for the national governments that cascades through the different levels of authority.

When looking at the broader context from which this and related EU Directives originate, another opportunity becomes apparent. The **climate crisis and its adverse impacts** that are predicted to continually worsen and are already experienced in disastrous flooding events and other natural disasters, urge the implementation of alternative approaches that address the complexity of these risks, especially in the light of “socio-economic developments” (p. 52 (Ritzema & Van Loon Steensma, 2018)) like urbanization, which also increase the vulnerability. Therefore, these external pressures can possibly push the implementation of the MLS approach. The climate crisis as a challenge for the society as a whole can be positioned in the ‘outer setting’, while it also fundamentally influences policy making on all levels as well as individual values and behavior, by that this opportunity seems also to be connected to the ‘inner setting’ and the ‘individuals’. When looking at the adverse impacts that are already experienced, for example structural breakdown of flood protection systems is positioned in the ‘inner setting’.

The following two opportunities are partly controversially discussed by scholars in literature but do reveal opportunities that can be beneficial for the implementation of MLS. First, Hegger et al. see an opportunity for the implementation of divers FRMSs in the possibly **increased efficiency in FRM** due to elaborate combinations of multiple measures (Hegger, et al., 2014). An argument, that could promote the implementation of MLS. Referring to chapter 2.2 though, the question arises again what is comprised within the term efficiency. Either way, this opportunity can be positioned in the ‘inner setting’, as it includes the combination of structural and organizational measures whose feasibility is highly context specific and dependent on the contemporary flood management culture.

Second, an argument brought up is the **high legitimacy and acceptance** that was observed with the implementation of MLS in the pilot study of Dordrecht (Hegger, et al., 2014). This experience can in turn be seen as an opportunity that fosters further implementation of MLS elsewhere. Again, due to local specifics in form of possibilities to implement MLS locally and societal attitude, this opportunity can be positioned in the 'inner setting'.

## 2.6 Conceptual Model

The central concepts that are referred to in this study and their interrelations are illustrated in the following conceptual model (Figure 6). The two central theoretical concepts are the MLS approach on the left and FR on the right, both highlighted in larger, bold font. The prominent arrow in the center of the model represents the implementation process of the MLS approach towards the normative goal of FR. During the implementation process barriers and opportunities affect this implementation process, which is illustrated through the small arrows showing in the direction of the implementation. The large, slightly transparent arrow on top, moves from FR back towards MLS and represents a feedback process from the intended concept towards the operationalizing concept. This feedback process reflects how FR as the normative goal informs the MLS approach.

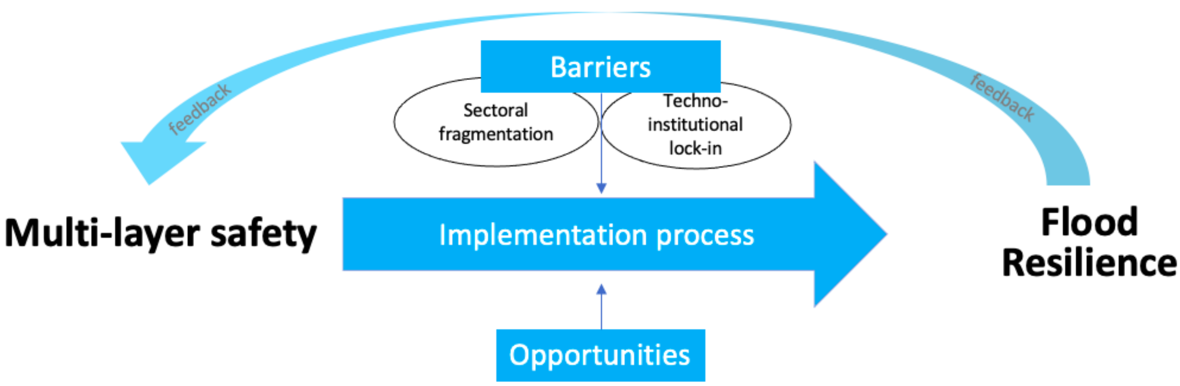


*Figure 6. Conceptual Model (by author)*

## 2.7 Answering theoretical sub-questions

Box 2. SQ1: What are the concepts of multi-layer safety and flood resilience?

Referring to the detailed elaboration in section 2.1, **flood resilience** is understood as a normative goal for FRM, which is conceptualized as a combination of robustness, adaptability, and transformability. By this threefold combination, the concept merges properties that relate to various forms of resilience along the development of this concept (2.1).

Based on section 2.2, **MLS** is a flood risk management approach that is comprised of various interrelated layers that aim to reduce the risk of flooding, which entails the reduction of the probability as well as the consequences of potential flooding incidents. Originally, the approach uses the three layers of protection, spatial adaptation, and emergency response, but got recently expanded with a fourth layer of resilient recovery (2.2).

*Box 2. Answering SQ 1*

Box 3. SQ2: How does multi-layer safety contribute to flood resilience?

Based on the sections 2.1 and 2.2, the MLS approach is understood as an operationalization of the components that make up the conceptualization of flood resilience. Thus, the MLS approach can contribute to the normative goal of flood resilience through the integrated implementation of measures on all three (four) layers that reduce flood risk and increase flood resilience. Thus, protection as the first layer of MLS contributes to robustness, the second and third layer of spatial adaptation and emergency response contribute to adaptability, and layer three and four of emergency response and resilient recovery contribute to the transformability.

*Box 3. Answering SQ 2*

Box 4. SQ3: Which barriers for the implementation of multi-layer safety can be derived from literature?

Based on the prior section 2.5 the barriers for the implementation of MLS derived from literature are illustrated in the following. The table incorporates a summary of the barriers and a categorization from B1-B7.

| | | |
|---|---|---|
| B1 | Sectoral fragmentation | The different sectors that need to be aligned and cooperate to implement the MLS approach follow different objectives and goals, represent different interests, and have different ways of acting and thinking, which hampers the implementation of MLS. |
| B2 | Techno-institutional lock-in | The historically rooted water safety system in the Netherlands of engineered, technical flood protection, which is anchored in the institutions and flood protection assets in place already and the resulting level of (perceived) safety, hampers the implementation of MLS. |
| B3 | Funding schemes and budgets | The different ways and sources of funding as well as diverging budget allocations for the layers of MLS, hamper the implementation. |
| B4 | Lack of knowledge | A lack of knowledge and expertise about alternatives to first layer flood protection hampers the implementation of layer two and three measures and the integration of all three layers. |
| B5 | High number of actors | The high number of actors that are involved with MLS exacerbate the implementation process. |
| B6 | Long-term vs. short-term planning periods | The different time horizons that are regarded within the planning processes of the actors of the different layers of MLS hamper an integrated implementation. |
| B7 | Uncertainty about flood risk | The uncertainty about future flooding scenarios and circumstances for the local context hampers the implementation. |

*Box 4. Answering SQ 3*

Box 5. SQ4: Which opportunities for the implementation of multi-layer safety can be derived from literature?

Based on the prior section 2.4 the opportunities for the implementation of MLS derived from literature are illustrated in the following. The table incorporates a summary of the opportunities and a categorization from O1-O4.

| | | |
|---|---|---|
| O1 | Formal pressure through supranational governance | As the Flood Directive 2007/60/EC is obligatory for the EU member states and demands the implementation of integrated flood risk management, it also fosters the implementation of the multi-layer safety approach on smaller scales. |
| O2 | More efficient flood risk management | Through the possibility of combining different flood risk management strategies and measures, flood risk management based on the multi-layer safety approach can be more efficient than traditional flood protection systems alone. This chance can be an opportunity to foster the implementation of multi-layer safety. |
| O3 | High acceptance and legitimacy | The multi-layer safety approach is associated with high public acceptance of the measures through which the legitimacy for the implementation increases, which can foster the implementation of multi-layer safety. |
| O4 | Climate change impacts and socio-economic developments | The increasing adverse impacts of climate change in combination with socio-economic developments like urbanization urge for more integrated and adaptive flood risk management and thereby foster the implementation of multi-layer safety through growing risks and vulnerability. |

*Box 5. Answering SQ 4*

# 3. Methodology

This chapter discusses the methodological approach to this research. In the beginning (3.1) the research strategy is presented and in the following section 3.2 the chosen research method is discussed. Ensuing, the data collection is covered regarding the data collection process as well as the approach to the data analysis. The chapter closes with a discussion about how the methodological limitations are dealt with and issues of ethics relevant during the data collection process.

## 3.1 Research strategy

A single case study is selected to best approach the topic of the local implementation of MLS in an urban context and thereby answer the main research question: 'What are the barriers and opportunities for the implementation of urban multi-layer safety to increase flood resilience?'. This strategy of a case study is suitable because it is regarded as "an ideal methodology when a holistic, in-depth investigation is needed" (p, 1 (Tellis, 1997)). Thereby, this strategy of examining the implementation of MLS in the case of Rotterdam guarantees a detailed and holistic analysis that covers all the layers of MLS and the different sectors involved and can address the entirety of the concept in a specific location.

Furthermore, the implementation process is highly contextual (Khan & Khandaker, 2016; Damschroder, et al., 2009) in a way that the implementation of a FRM approach depends on the local specifics reaching from hydrological characteristics to the institutional setup, which supports the specific focus on one case considering such contextual factors.

## 3.2 Research methods

A qualitative research method is used in the form of semi-structured interviews. This interview approach within the qualitative methods is widely used in spatial sciences (Longhurst, 2010). While keeping a general order of questions that should be covered, semi-structured interviews offer high flexibility during conducting the interviews and thereby allow going deeper into specific content with the individuals and adjust to their perspectives (Horton, et al., 2004; Longhurst, 2010). That is especially valuable, because the interviewees that cover a diverse group of actors are asked about the barriers and opportunities for MLS implementation from their perspective as well as the points of contact with the concept in their work field. Still the interviewees are all asked roughly the same questions, which allows to identify patterns and relate the data. Besides the identification of barriers and opportunities for MLS implementation in literature to supplement the questionnaire content with deductive elements, the semi-structured interviews are applied as a 'stand-alone method'.

## 3.3 Case selection

The city of Rotterdam is selected as the case study region for several reasons. The geographic location of Rotterdam in the Rijnmond-Drechtsteden delta, the topography of the region, and the dense urbanization, cause significant flood risk for the city. All sorts of flood risks are predicted to increase with climate change, leading to significant challenges regarding coastal, fluvial, and pluvial flooding caused by sea level rise and intensifying weather patterns (Eraydin & Taşan-Kok, 2013), which necessitates to concern oneself in this local context with the implementation of approaches like MLS to increase FR. Moreover, Rotterdam is also a relevant case, as significant parts of the city lie outside the primary dike system, which underlines the importance of considering alternative FRM measures like they are included in the MLS approach.

All of the above has led to Rotterdam being regarded a frontrunner in climate change adaptation and spatial planning (Eraydin & Taşan-Kok, 2013) and the observation that "attempts to deal with urban resilience, climate change, adaptation and mitigation are more advanced in Rotterdam than in most other Dutch municipalities" (p. 212 (ibid.). Thus, for studying the implementation process of MLS, Rotterdam is a relevant case study that can provide insights from the comparatively established processes of dealing with climate adaptation and MLS.

## 3.4 Data collection process

The data collection process starts with the identification of actors and sectors that are involved and relevant for the implementation of MLS in the city of Rotterdam. This is structured by the three layers of the MLS approach that are considered in Dutch policy, namely the National Water Plan, and the geographical range of responsibilities and influence that involves the national, regional, and local level of authority. In line with that, the selection of interviewees reflects the variety of actors and sectors that need to be integrated for the implementation of MLS, and thereby cover the different perspectives on the barriers and opportunities that are experienced during the implementation process. Table 3 shows the structure of the interviewees to illustrate the selection of sources for the data collection process. It also includes the levels of authority and general focal layer of the MLS approach that characterize the sources for the data collection. These are specified with the interviewee's organization as the general actor, the individual interviewee, and the professional position of the interviewee within their organization.

*Table 3. Interviewee Framework (by author)*

| Level of authority | Interviewee's organization | Interviewee | Position of Interviewee | MLS layer |
|---|---|---|---|---|
| National/regional | Rijkswaterstaat / Delta Programme Rijnmond-Drechtsteden | Pieter Jacobs **(Interview_3)** | Programme Manager Delta Programme Rijnmond-Drechtsteden | 1, 2, 3 |
| Regional | Safety Region 17 Rotterdam-Rijnmond | Geanne Vink **(Interview_5)** | Policy Officer - Risk and Crisis Management Department - Spatial Security Team | 2, 3 |
| | Safety Region 17 Rotterdam-Rijnmond | Mark Schipper **(Interview_6)** | Senior Policy Officer - Crisis Management Department | 3 |
| | Safety Region 17 Rotterdam-Rijnmond | Jacob Seen **(Interview_8)** | Operational Disaster Manager | 3 |
| | Schieland & Krimpenerwaard Water Board | Arie de Gelder **(Interview_2)** | Head of the Policy Advisors for Water Safety and Flood Protection | 1 |
| | Delfland Water Board | Mark Flanagan **(Interview_10)** | Programmer Asset Flood Defenses | 1 |
| | Hollandse Delta Water Board | - **(Interview_9)** | Policy Advisor Flood Protection | 1 |
| Local | Gemeente Rotterdam - Urban Management/Water Strategy and Development | Vera Konings **(Interview_1)** | Senior Flood Risk Advisor | 2 |
| | Gemeente Rotterdam – Urban Development | Marlies van der Maarel **(Interview_11)** | Strategic Urban Planner | 2 |
| | Rotterdam The Hague Airport | Steven van der Kleij **(Interview_7)** | Project Director Airport Development | - |
| | Port of Rotterdam | Robert Ranke **(Interview_4)** | Advisor Environmental Management / Policy & Planning Havenbedrijf Rotterdam N.V. | 2 |

Following on the identification of the general actors, they were contacted via email, based on an online search for contact details. The initial request for an interview, including a brief introduction about the researcher and the research project, is prepared consistently in content, and minimally modified to address the recipient individually. After acquiring individual contact details and the confirmation of the willingness for an interview, an online meeting appointment is arranged, and the interviewee receives an invitation for a meeting using the online application for video conferences 'Zoom'.

The 11 interviews are conducted between the 2nd of June 2021 and the 21st of January 2022 and follow a semi-structured interview scheme of various questions and sub-questions (see appendix). The development of the questions follows a guideline of first inquiring about their professional background and current position, familiarity with the concept of MLS and thoughts about the case study region. Thereby, it is intended to make the interviewee feel comfortable and to receive basic information before leading on to more concrete questions that are oriented towards the central research question. The main part of the questionnaire and the interview structure builds on the opportunities and barriers for the implementation of MLS in Rotterdam. To get the most insights on the interviewees perspective and simultaneously inquire the practitioners' opinions on opportunities and barriers discussed in literature, a combination of inductive and deductive questions is selected. Thereby the deductive questions state specific barriers and opportunities that the interviewee responds to, while the inductive questions ask openly for the interviewee's experiences. To not manipulate the answers regarding the opportunities and barriers, the starting point for these subject areas is an inductive question: 'What barriers did you experience, or do you expect for the implementation of multi-layer safety in Rotterdam?' and 'What opportunities did you experience, or can you expect for/from the implementation of MLS in Rotterdam?'. Following on that, the deductive element enquires the opinion on the opportunities and barriers identified in literature (see chapters 2.4 and 2.5).

The interviews are recorded with screen and audio recording as well as additional audio recording on a secondary device to plan for possible technical problems. Subsequently the interviews are transcribed manually to obtain written transcripts of the interviews that are suited for data analysis.

During the research and data collection process after the first interviews were conducted the researcher noticed shortcomings regarding the deductive questions about the opportunities, such as the clear differentiation between opportunities for and from the implementation of MLS. Therefore, a short follow up questionnaire was developed to address the previously dissatisfying coverage of the opportunities for MLS implementation. This follow-up strategy was applied to close the gap between the interviews conducted prior and past this adjustment. Therefore, the interview transcripts are partly complete and partly supplemented with the written answers by those interviewees that were interviewed prior to the updated interview scheme.

Furthermore, the regional actor 'Hollandse Delta Water Board' asked for a deviation due to various individuals' responsibility for different elements of the topic and a language barrier, especially regarding the correct technical terms. Thus, for this actor there is no individual interviewee indicated in the table, and a questionnaire of open questions is prepared that is sent to be filled out and received. This questionnaire follows the content of all the other semi-structured interviews that were conducted face-to-face via 'Zoom', but additionally involves brief explanatory elements, as content of the questions cannot be explained in person in case of queries.

## 3.5 Data analysis

To analyze the data collected throughout the 11 interviews, the written transcripts of each interview are uploaded to the password protected qualitative data analysis software ATLAS.ti. Ensuing, preliminary coding is applied through which different code categories are created, that are based on the sub-questions (SQ 3.2; SQ 4.2; SQ 5; SQ 6) and are represented in the following Figure 7 on the left.

Regarding the responses for the deductive questioning (Figure 7. first six categories), the form of simultaneous coding is applied using the categories (Figure 7. left side) and codes (Figure 7. right sight). For the inductive questioning the two inductive categories are applied each simultaneously with the codes that are created along the coding process using a descriptive coding technique. Throughout three cycles of coding, some of the codes are adjusted, specified, merged, and deleted to result in the final 62 codes that are illustrated through the tables on the right side in Figure 7 below. The complete figure represents the final coding scheme and should clarify the different categories and codes (code groups). Ensuing the coding process, the data was analyzed and after further merging, classification, and correlation of the coded data resulted in the final consolidation of barriers and opportunities, which is presented in the following chapter of results.

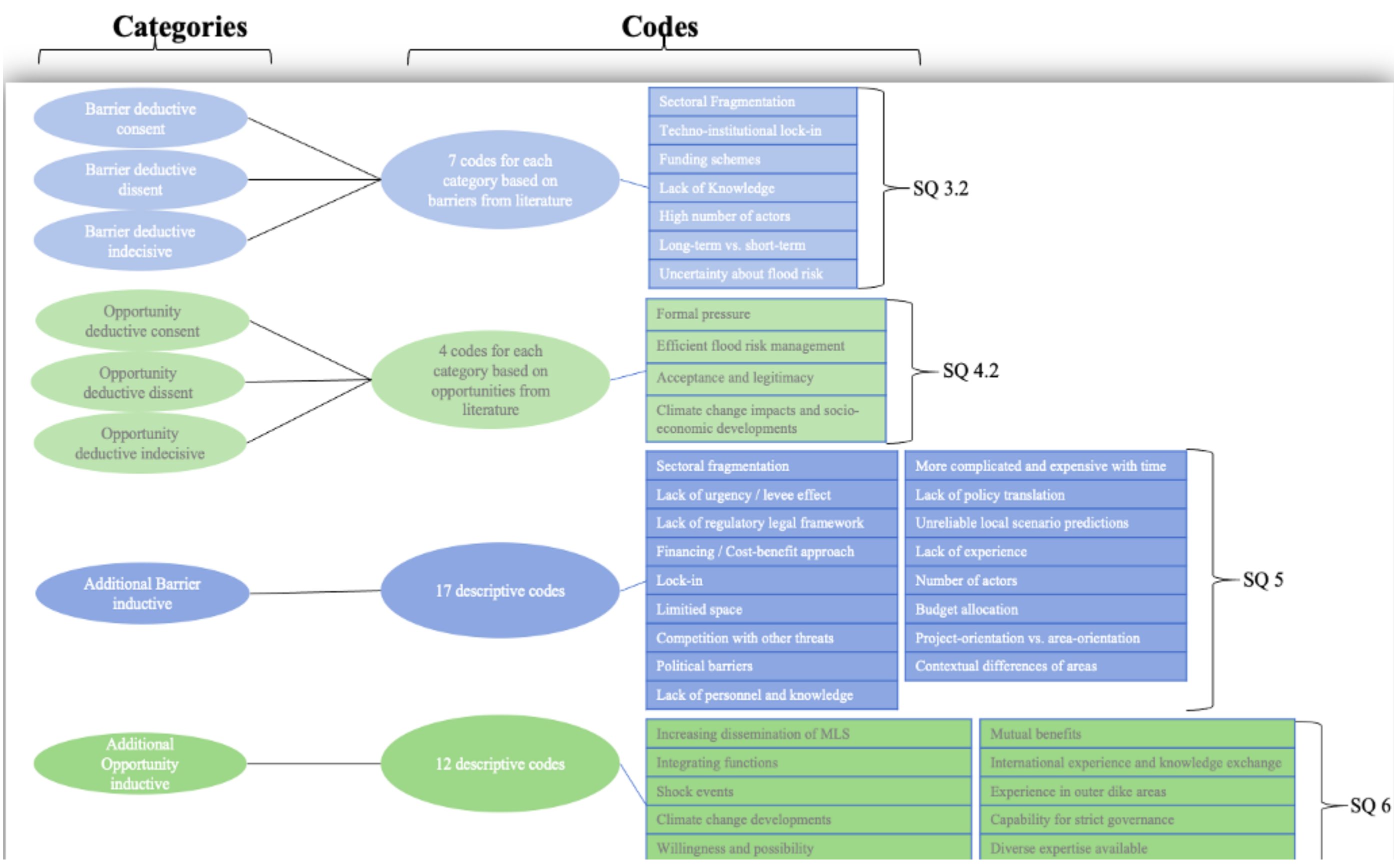


*Figure 7. Coding scheme (by author)*

## 3.6 Dealing with limitations

Looking at the limitations of this research's methodology, due to the individuality of every single interview and the concomitant effort of acquiring appropriate participants, conducting, transcribing, and coding the interview, the number of interviews conducted states a limitation for this research method in contrast to quantitative approaches. Nevertheless, what goes along with that is the detailed involvement with the interviewees and the comprehensive content of the interviews, which offers insights that could not be acquired with a quantitative method.

Furthermore, with the semi-structured way of conducting the interviews the opportunity of flexibility simultaneously states a possible limitation for data validity, which is dependent on how close the interviewee sticks to the initial question or departs from it causing potential challenges to compare the results (George, 2022). The method offers more room for deviation compared to surveys or completely structured interviews. Nevertheless, this aspect also entails opportunities to allow exploring new perspectives and to add room for insights that the researcher might have not considered.

Lastly, the dependence on response to the interview request during the acquisition of interviewees can be a limitation regarding the completeness of the data. When no individual from an identified central actor group can be reached, this perspective cannot be included. This is unfortunately the case for private companies involved in urban development projects. This setback is compensated through multiple interviewees that are at least involved with these actors on a regular basis and other private actors like the Rotterdam The Hague Airport.

## 3.7 Ethics

Regarding ethics, there are two main issues that are regarded as relevant, which are "confidentiality and anonymity" (p. 111 (Longhurst, 2010)). Therefore, the recorded interviews are saved and stored in a password protected cloud and the interviewees are asked before starting the interview: if they comply with the interview being recorded and if they consent to the appearance in the thesis as a source including their name and professional position. The interviewees gave their informed consent for these aspects verbally, before starting the interview. With one exception of the written interview with the representative of the Hollandse Delta Water Board where no clear consent was given regarding the mention of names, the other 10 interviewees did consent with the questions above. Furthermore, the interviewer assures that all data will be handled confidentially and will not be forwarded to third parties, and lets the interviewee know that he/she can cancel and leave the interview at any point without having to give a reason. Finally, as it is popular in practice and keeps the source involved in the research, the interviewee is offered to be provided with the results of the thesis as soon as the project comes to an end.

# 4. Results

In the following the results of the data collection and analysis of the thesis are presented. The structure of this chapter builds on the remaining sub-questions of this research that have not been covered within the theoretical framework. At first the general reactions of the interviewees to the barriers and opportunities identified in literature are discussed and ensuing supplemented with their response to inductive questioning about additional barriers and opportunities they experience.

The sources that are referred to in the following, are classified as 'Interviews 1-11' (see table 3, chapter 3). Whenever 'Interview_1-11' or 'Interviewee_1-11' is mentioned in the following, it relates the content to the respective interview.

## 4.1 Barriers for the implementation of MLS

SQ3.2: Are the identified barriers also recognized in the practice of implementing multi-layer safety?

SQ5: What are additional barriers that are experienced or expected by practitioners?

To provide an overview of the consent or dissent of the interviewed experts from practice with the identified barriers for the implementation of MLS in literature, the following table 4 illustrates their general reaction. Whenever the cells in table 4 show an 'N' (no), the interviewee dissents with the barrier being experienced or expected in practice from their perspective. Whenever the cells show a 'Y' (yes), the interviewee consents with the barrier being experienced or expected in practice from their perspective. The '?' represents an indecisive opinion and 'Y/N' represents arguments for and against the barrier. The columns B1-B7 refer to the barriers identified and discussed in the second chapter (box 3).

*Table 4. Interviewees consent/dissent with deductive barriers (by author)*

| Interviewees | Stakeholder | B1 | B2 | B3 | B4 | B5 | B6 | B7 |
|---|---|---|---|---|---|---|---|---|
| Vera Konings (1) | Municipality | Y | Y | Y | Y/N | ? | N | Y |
| Marlies van der Maarel (11) | Municipality | Y | Y | Y | Y | Y | Y | Y |
| Geanne Vink (5) | Safety Region | Y | Y/N | Y | N | Y | N | N |
| Mark Schipper (6) | Safety Region | Y | N | Y | N | Y | Y | N |
| Jacob Seen (8) | Safety Region | Y | N | Y | Y | Y | Y | N |
| Arie de Gelder (2) | Water Board | Y | N | Y/N | N | Y | Y | Y |
| Mark Flanagan (10) | Water Board | Y | N | Y/N | N | Y | Y | ? |
| ○ (9) | Water Board | Y | N | N | ? | Y | N | ? |
| Steven van der Kleij (7) | Airport | Y | N | Y | N | ? | ? | N |
| Robert Ranke (4) | Port (unembanked) | N | N | N | Y/N | Y | N | ? |
| Pieter Jacobs (3) | Delta Programme/RWS | Y | Y | Y | N | Y | Y | N |

Table 4 illustrates the response to the deductive questioning regarding the barriers identified in literature, the following figure 8 shows the barriers for the implementation of MLS in Rotterdam that are the result of the inductive questioning conducted prior to the deductive questioning during the interviews. The numbers relate to the amount of phrases that are related to the respective barriers throughout all eleven interviews.

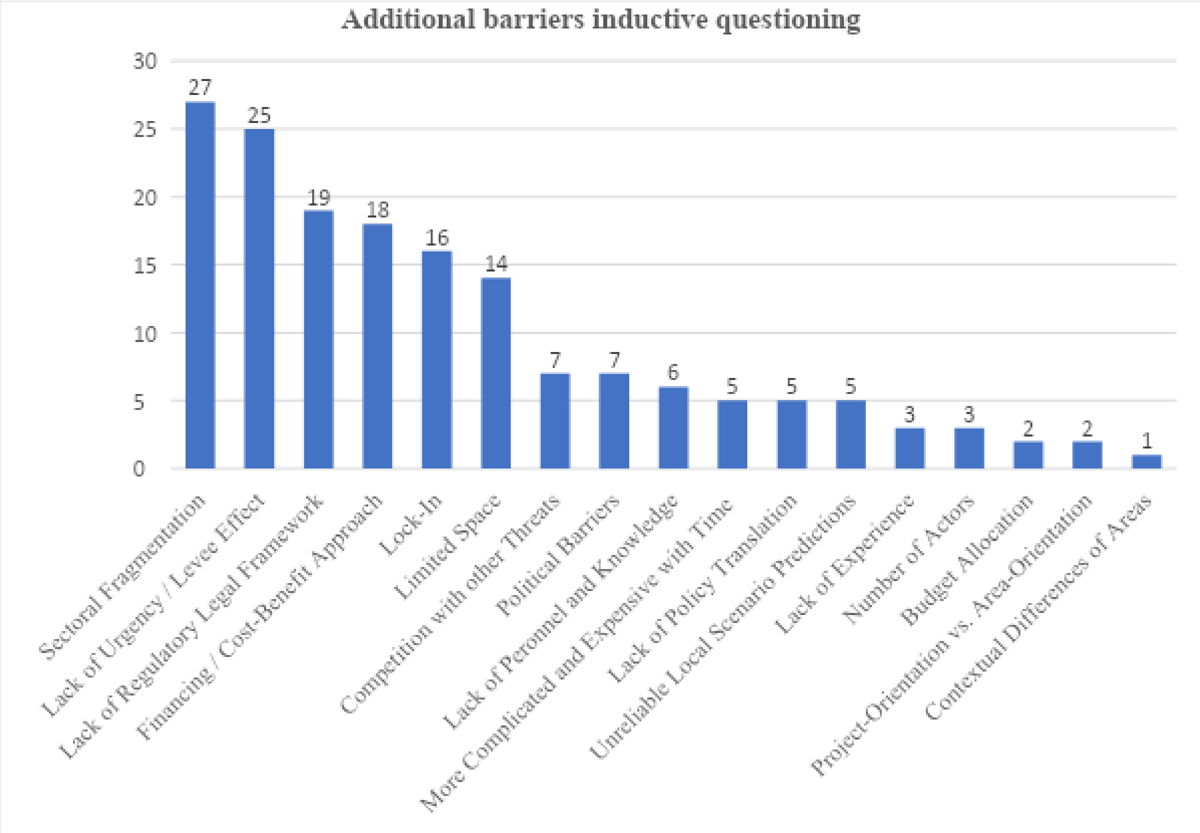


*Figure 8. Numbers of coded phrases about additional barriers from inductive questioning (by author)*

In line with chapter 2, there are two overarching barriers: **'sectoral fragmentation' (OAB I)** and **'techno-institutional lock-in' (OAB II)**. Additionally, as these two barriers are overarching, there are several barriers identified that are associated with either one of these or both and consequently labeled as **associated barriers 'AB I', 'AB II', or 'AB I/II'**. These are associated in a way of showing more specific barriers that feed into the broader phenomena of the overarching barriers. The overarching barriers are discussed through **building blocks** that structure the reasoning of these barriers. Finally, some barriers do not clearly relate to this structure and therefore are referred to as **additional barriers (AddB)**.

### 4.1.1 Overarching barrier I (OAB I): Sectoral fragmentation

Sectoral fragmentation is the most recognized barrier throughout the interviews. It was coded 27 times during the data analysis. The layer one representatives from the water boards (Interviews_2, 9, 10) all agree with sectoral fragmentation as a barrier for the implementation of MLS. According to interviewee_2: it is "a constant barrier that needs a lot of attention, despite already existing efforts for cooperation"**.** Or, as put by interviewee_9: **"**In my opinion, the biggest challenge is to have a good alignment and cooperation at all layers". Interviewee_7 experienced this in the project of the Rotterdam the Hague Emergency Airport: "when it is a combined responsibility of several actors then it becomes tricky" (Interview_7). This broad agreement is in line with sectoral fragmentation as a barrier for MLS discussed in literature for instance in the form of barriers for the adoption of IFRM as a "fragmented governance structure for flood management" (p. 2 (Mercado, et al., 2020)) and observed as well in the case of Dordrecht (van Herk, et al., 2014). Only interviewee_4 does not experience this barrier (Port of Rotterdam), as he sees MLS as "the approach and the consequence of taking the puzzle at various layers and afterwards implementing them in one overall strategy, which leads to a clearer sense of what the possibilities are overall". Such a perspective and different possibilities in the unembanked port areas in working with MLS also aligns with research focused on this very part of Rotterdam (de Moel, et al., 2014). The interviews shed light upon multiple building blocks of this barrier. These show causes for sectoral fragmentation in the context of implementing MLS.

**Building blocks of sectoral fragmentation**

A first building block of sectoral fragmentation is the fragmentation between the first and second layer among others outlined in the single purpose orientation of layer one, compared to the more diverse focus of layer 2. Indeed, "a gap between urban planners and water management in general" (Interview_1), is something Interviewee_1 experienced when coming from an urban planning background to work with flood defense experts, who have a clear focus on dikes (Interview_1). Interviewee_10 addresses this gap from a water board perspective and sees a barrier in the multiple goals and interests of organizations that are responsible within the second layer of MLS besides flood risk (Interview_10). On the other hand, while the diverse focus of layer two organizations is seen as a barrier by a layer one representative, the single purpose of layer one protection would lack "a mutual gain right now" following the comment from a layer two perspective (Interview_1). This contrast in describing the fragmentation indicates the barrier quite well, which is also supported by literature in referring to fragmentation of spatial planning and water management on various levels covering differences in governance, actors' relations, the institutional context, and approaches (Hartmann & Driessen, 2017).

Another building block of this barrier is about the conflicts arising from multi-functional usage of flood risk measures. Interviewee_1 refers to plans of houses on dikes or right next to dikes, which however would not be compatible with dike building regulations (Interview_1). To convey the claim of space around the dike for later reinforcements to the urban planning realm is experienced as challenging (Interview_1). Interviewee_3 gives an example of these conflicting interests, which shows the fragmentation of layer one and two again. Thus, he talks about an apartment block in Rotterdam that is being built with the ground floor based on the dike. This would make further enforcement of the dike impossible, while the building is also not planned in an adaptive way to cope with overtopping of the dike (Interview_3). Interviewee_10 also mentions problems occurring from building near and on top of the dikes, which is not coordinated well amongst the different sectors involved (Interview_10). Though, if collaboratively planned, multi-functional approaches are discussed in literature as possible synergetic solutions to face flood risk especially for dense urban areas, but in line with the interviewees also multiple challenges are acknowledged about engineering and bureaucratic processes and conflicts between different views of spatial planning and water management (Al, 2022).

The next building block of sectoral fragmentation includes a fragmentation of private developers and a lack of flood risk being integrated to different domains in the urban realm. For instance, it is mentioned that “architects and city planners, they are not aware if they are building in Rotterdam, not often they will think of flood risk” (Interview_1). According to that, the issue of flood risk is not considered in various developments, and if deficiencies in that regard are expressed in the context of water tests (‘watertoets’) by the water boards, the projects are often too far advanced to interfere (Interview_1). For this purpose, Interviewee_3 gives another example of the “football club Feyenoord, who wants to build a new stadium and they want to build it partly outside the dike, so close to the river, in fact the whole stadium is on top of a dike” (Interview_3). The cooperation with private actors is especially seen as a challenge when aligning FRM with the second layer, as they would follow primarily economic interests (Interview_3). Interviewee_7 from the airport also highlights the barrier of differences in how private and public bodies operate in terms of governance and financing (Interview_7). The engagement with private property in terms of flood risk measures is described as “a different ball game” (Interview_10).

In literature the water tests are referred to as a “statutory requirement” (p. 21 (Stead, 2014)), which does not seem to work appropriately in practice. Furthermore, within a comparative study about Rotterdam and Hamburg, incentives for private actors in Rotterdam are mentioned that should for instance promote climate adaptive innovations like floating buildings (Huang-Lachmann & Lovett, 2016), which seems to remain on a pilot level when linked with the data.

The fourth building block concerns fragmentation between the third and the first layer and is about the different view on or perception of the significance of flooding and its impacts on society. Accordingly, interviewee_6 from the Safety Region experiences a shift from working for a water board to working for the safety region. Compared to flood risk being the core topic and approached as daily business at the water board, the risk of flooding is “framed as a big issue” within the safety region (Interview_6). Also, when considering a flooding scenario, the definition of the water boards would be rather technical, “whereas the safety region also considers the whole effect on the community”

(Interview_6). Exemplified by a scenario of 30 cm of water in houses, the water board would see this as no cause for alarm, while this can already have severe impacts for the individual citizens and communities (Interview_6). Interviewee_8 also sees this fragmentation between "flood management experts and disaster management experts that would be "two kinds of a group, which think completely different" (Interview_8).

Finally, a lack of influence of the third layer to take part in preparatory measures on the second layer is mentioned. Thus, Interviewee_8 addresses that he as a disaster manager cannot influence the "proaction phase" and how the infrastructure is designed for the future (Interview_8). Accordingly, from a disaster management perspective some areas should not be inhabited, but decisions about that would be made by someone else (Interview_8). While the gap and fragmentation between layer one and two finds ample attention in literature (Hartmann & Driessen, 2017; Woltjer & Al, 2007), research on such issues around the integration of layer three with the others seems to fall short so far.

#### 4.1.1.1 Associated barriers (AB) with OAB I

The following associated barriers are associated with the overarching barrier in a way that they are generally referable to sectoral fragmentation but do bring up specific barriers.

The first of these barriers associated with 'sectoral fragmentation' (OAB I) that was already addressed in chapter 2 is about the **'number of actors'** (**AB1 I)** that are involved with the implementation of MLS. The clear consent with this barrier runs through almost all interviewees (Interview_2, 3, 4, 5, 6, 8, 9, 10, 11). Accordingly, it is experienced that "it takes a lot of effort when you have a lot of parties involved" (Interview_2). Nevertheless, the necessity of involving various actors is acknowledged. The negativity about this barrier is also relativized: "yes it does make it more complicated, and it does hinder the process, but it is not to say it is a bad thing." (Interview_10). A clear association with 'sectoral fragmentation' (OAB I) is shown in the different agendas and political strategies of the different actors that are mentioned (Interview_5), as well as the differing priorities of flooding within the agendas of the various actors (Interview_6). To work together on an operational level, the high number of actors would cause complex and elaborate processes that involve multiple disciplines, diverse knowledge, and unclear responsibilities (Interview_3, 11, 4). The increasing complexity and risk of conflicts due to the higher number of actors involved in implementing MLS is equally acknowledged in literature (Hegger, et al., 2014; van Herk, 2014). Potential solutions to address this barrier can be found in boundary spanning and collaborative planning.

The second associated barrier is about '**long-term vs. short-term planning periods' (AB2 I)**, which is agreed upon by most interviewees (Interview_11, 6, 8, 3, 10, 2). According to that, this distinction is referred to in the form of a different time focus between layer one and three that contrasts the long-term focus on dike stability with crisis management that would rather prepare the "organization on crisis which happens now not in the coming hundred years" (Interview_6). Furthermore, the barrier is related with the integration of layer one and two. This is mainly about the planning horizon of buildings that would not consider future flood risk sufficiently (Interview_3). Additionally, the lack of coordination of planning and maintenance periods between dikes and buildings or infrastructure in the vicinity (Interview_3), would state a barrier especially for multi-functional use of dikes (Interview_10). Therefore, this barrier seems to be associated to the overarching barrier of 'sectoral fragmentation' in the form of conflicts about time and space that hamper MLS implementation. Detached from individual layers, the temporal focus of political decision-makers is brought up as mostly focusing on short-term results and tends to neglect concrete consideration of long-term investments that are crucial to implement MLS (Interview_2). That such considerations of temporal elements are important for the implementation of MLS is for instance reflected in literature in the context of the "integration across temporal scales" (p. 105 (van Herk, et al., 2014)) as part of the "self-reliance strategy" (p. 105 (ibid.) referring to the locality of Dordrecht.

On the other hand, it is mentioned that: "Differences in planning periods don't have to be a barrier" (Interview_9) and even can be a "good thing" (Interview_5) to cover different planning horizons. In fact, Interviewee_1 from the municipality does not even see that much of a difference in the planning periods of dikes and housing developments, which makes it "a less big barrier" (Interview_1) in her opinion, which is similarly the case for developments in the port (Interview_4).

The third associated barrier is summarized as '**scaling' (AB3 I)**. This barrier refers to the status quo that would lack the incorporation of the bigger picture. Thus, the planning of FRM at the scale of a whole area is lacking and the interventions to reduce flood risk do not bring "mutual gains" (Interview_1). Furthermore, the contextual differences of areas are also mentioned as hampering the implementation of an integrated MLS based FRMS. Consequently, it would be "the hard thing with FRM, there is quite a big difference for each spot" Interview_1). Thus, this barrier is associated with 'sectoral fragmentation' in a sense of geographical scale and scale of authority, that results from the conflict between project-orientation and area-orientation. In line with that, in literature it is referred to the "integration across spatial scales" (p. 104 (van Herk, et al., 2014)) as a vital element for MLS, due to the multi-scalar nature of flood events.

The next associated barrier is '**limited space (AB4 I)'** in Rotterdam and refers to spatial competition. Accordingly, interventions in the urban sphere addressing flood risk compete among each other and with other forms of using the rare space in Rotterdam (Interview_1, 3, 5, 9, 10, 11). This competition is mentioned between dikes and housing (Interview_1, 3), dikes and business developments (Interview_3), developments and open spaces (Interview_3), and flood adaptation measures and various other spatial claims (Interview_10). This is not only the case for new constructions, but also for the existing cityscape that would be completely built already, inside, outside, and on top of the dikes (Interview_3), which would make it complicated to add new functions or combine existing ones (Interview_11). In line with fragmented sectoral interests (van Herk, et al., 2011), this barrier brings in conflicts in the build environment.

The fifth associated barrier is the '**competition with other threats' (AB5 I)**. Accordingly, competition is not only experienced for the build environment, but also between flood risk and other risks. Especially from the perspective of the Safety Region, there are several other risks that need to be considered and managed, of which the ones with higher probability get the most attention on a regular basis (Interview_6, 8). Therefore, not only fragmentation between the sectors, respectively layers, but also inner-sectoral fragmentation is experienced as a barrier. Flood risk, just being one of many issues and objectives in competition about resources is discussed in literature mostly with a focus on urban planning (van Herk, et al., 2011) and seems to cover mostly the second layer, while again the third layer is covered less in that regard.

Finally, the fifth associated barrier is the '**lack of policy translation' (AB6 I)**, which brings in another form of fragmentation. According to that, most people involved on a project level would not know about national policies like the MLS approach, and therefore skip respective ambitions (Interview_1). In that regard, a gap between policy and practice is mentioned (Interview_6, 8), which would need more communication and appropriate translation of flood risk issues towards the respective stakeholders (Interview_2). Thus, this barrier brings up a kind of vertical fragmentation along the levels of authority that hampers eventual implementation on the local level.

#### 4.1.1.2 Reflecting on sectoral fragmentation along the three layers

A central finding is that the overarching sectoral fragmentation is also reflected in differences between the layers (i.e., the respective interviewees) opinions on several barriers for MLS implementation and suggests in some cases allocation of layer-specific barriers. What becomes thus evident from the above is that several barriers are experienced in the sectors concerned with the layers two and three of MLS. This implies a generally more challenging role for such layers of MLS, compared to the first layer and the long-established water sector, which also highlights the interrelatedness with the second overarching barrier 'techno-institutional lock-in', for which the following chapter gives more insights.

Nevertheless, the integration of all layers and concomitant alignment of the sectors is a challenge for everyone, not the least depicted in the strong overall support for the overarching barrier of 'sectoral fragmentation'. In the light of a paradigm shift in flood management towards FR this barrier with its associated components and building blocks confirms the challenge of transitioning from a technical and homogenous approach towards an integrated and heterogenous approach. Consequently, when aiming for FR as an interaction of robustness, adaptability, and transformability (Restemeyer, et al., 2015), it seems worthwhile to be mindful about the risk of flattening the currently fragmented sectors into one, but rather embrace the diversity to create a well-coordinated playing field of multiple competencies. Furthermore, referring to the CFIR, the fragmentation on various scales shows the importance to consider the different contexts and settings of the implementation process with different influencing factors and ones more emphasizes the complexity and messiness of implementing a new approach into an existing context.

### 4.1.2 Overarching barrier II (OAB II): Techno-institutional lock-in

The second overarching barrier, the '**techno-institutional lock-in' (OAB II)**, is recurringly referred to in literature in various forms (van Herk, et al., 2015; Mercado, et al., 2020; Hartmann & Driessen, 2017) that will be referred to in more detail in the course of this section. Contrary to the overarching barrier of 'sectoral fragmentation', this barrier finds less consent throughout the interviews. Seven out of eleven interviewees dissent with this barrier, while only three consent.

**Building blocks of techno-institutional lock-in**

The first building block is about the technological and institutional set-up of water management with a layer 1 focus in the Netherlands. Why interviewees do not recognize this barrier can be seen in the fact that it is embraced as "one of the solutions" (Interview_2) and would be "historically well-arranged and does not create any obstacles" (Interview_9). The legislative structure and overall framework of how flood risk is approached, is described as no hindrance, even though it is acknowledged that changes will have to be made for future scenarios, especially looking at the integration of the different layers (Interview_10). The techno-institutional protective flood management is described as a fundamental necessity in the Netherlands (Interview_6). Furthermore, it is commented that the traditional water management bodies have been adapting to the changing circumstances of climate change and broadening their scope (Interview_8). These explanations support the general and prevalent flood management system, whereas the port area is neither technologically nor institutionally locked-into that system and consequently in "direct connection with the sea and destined to work with the various layers" (Interview_4).

The second building block is rather about an informal institutional lock-in, which is supported by a minority of interviewees (Interview_1, 3, 11) that acknowledges this barrier and brings forward arguments that reflect an informal institutional lock-in as also emphasized in literature with the "engineering approach to floods [...] being [...] deeply rooted not only in cultural beliefs" (p. 150 (Hartmann & Driessen, 2017)). Accordingly, interviewee_1 addresses the way of thinking as part of the lock-in situation as a barrier for MLS implementation: "for every topic about FRM, the first thing a Dutch person thinks of is a dike, storm surge barriers, delta works" (Interview_1). The prevalence of the current paradigm of first layer protection from the water is mentioned by interviewees in terms of the attitude and procedures (Interview_1, 2, 5).

The third building block is about the neglect of layers two and three compared to the prevalent layer one as in for example the "Delta law, that projects have to be done in an effective and efficient way, so that means that spatial developments or adding natural or ecological quality to the things that you do, well that is not being a part" (Interview_3). The "second and third layer is all just based on extra judgment" (Interview_5).

Interestingly, multiple interviewees mention barriers that are clearly associated with a techno-institutional lock-in without explicitly consenting with the actual lock-in, which results in a high number of coded phrases (figure 8) that feed into this overarching barrier. Therefore, in the following these associate barriers are discussed and related to literature.

#### 4.1.2.1 Associated barriers (AB) with OAB II

Like in the prior section about OAB I, the following barriers are associated with the overarching barrier OAB II in a way that they feed into the broad phenomenon of a techno-institutional lock-in, while being a specific barriers by itself. The first barrier associated with a 'techno-institutional lock-in' (OAB II) is a **'lack of urgency / the levee effect' (AB7 II)** with 25 coded phrases throughout all interviews. Due to the high level of protection through dikes and storm surge barriers in the Netherlands and the consequential low probability of flooding and a feeling of safety, interviewees mention a lack of urgency to incorporate additional measures of layer two and three into the FRMSs, which hampers the implementation of MLS (Interview_1, 2, 3, 5, 6, 7, 9). This would refer to the citizens of Rotterdam as well as to local politicians from whom the respective urgency to promote swift implementation of MLS is experienced as lacking (Interview_5). Thus, the current level of flood safety shades over the existence of remaining risks (Interview_9) and the severe consequences that would occur if the layer of protection was to break.

Such comments about lacking urgency refer well to the technical lock-in as a part of the overarching barrier, which finds ample confirmation in literature. For instance, in the context of uncertainties about flood risk that would "contribute to a technical lock-in into 'standard' solutions such as large structural defence measures" (p. 307) (van Herk, et al., 2011), or the prior mentioned 'levee effect' that is about the carefree development and behavior behind a dike and consequential felt absence of risk (Baan & Klijn, 2004). This effect is directly referred to by Pieter Jacbos, accordingly the economic values in Rotterdam have increased due to the protection set up following the 1953 flooding, but the norms for the dikes remain the same (Interview_3). In line with that, it is mentioned that despite the very low probability, due to the development behind the dikes, the consequences of a flood would be very high, which "can be easily forgotten" (Interview_2).

Building on this low probability and low urgency, Interviewee_1 mentions that it would be *"quite a hard discussion because you must discuss ones in 30,000 years maybe there is a flood so what is reasonable to ask from project managers* who *are building new houses or half villages, new urban areas. Why should they make extra costs, reduce the risk of what is probably not going to happen within their lifetime?"* (Interview_1). Also, for the Safety Region the low probability and low urgency of flooding risk is a barrier as the issue is possibly displaced by risks with higher probability (Interview_6), which also refers to AB4 I and thereby shows an interrelatedness also between the overarching barriers.

The next associated barrier is the '**lack of a regulatory legal framework' (AB8 II)**. What is mentioned several times throughout the interviews is that the standards and regulations for first layer protection are clearly formulated and legally binding, but layer two and three measures as well as the integration of the layers are optional and cannot be forced upon parties involved (Interview_1, 3, 5, 9, 10,11). Accordingly, the regulatory framework would be designed for the current paradigm of protection from the water and would facilitate its prevalence (Interview_3, 5).

A "big difference between policy and something you have to do" (Interview_1) is emphasized as a barrier for MLS. Private parties in urban developments cannot be obliged to build in a flood adaptive way, nor to coordinate plans with future dike reinforcements (Interview_3, 11). Accordingly, this barrier is mainly seen as an issue for layer two measures and the integration between layer one and two (Interview_10).

This barrier is repeatedly backed in literature as in: "the implementation of the multi-level safety concept is hampered by current regulation [...]" (p. 10 (van Herk, 2014)). Also, in line with the lack of enforcement capacity to tackle flood risk in urban planning it is referred to "weak enforcement and low compliance with building restrictions" (p. 2 (Mercado, et al., 2020)). Finally, a direct link to the prevalent flood protection system is made as the barriers for MLS implementation would "include existing safety norms" (p. 4137 (Hegger, et al., 2014)).

#### 4.1.2.2 Reflecting on the techno-institutional lock-in

Despite this barrier finding ample support in literature (Mercado, et al., 2020; van Herk, et al., 2015; Hartmann & Driessen, 2017), the initial data shows mostly disagreement with the explicit designation of a lock-in of the protective flood management paradigm as a barrier for MLS implementation. Nevertheless, the data also includes some indications for the existence of a lock-in, that are in line with the literature. This becomes apparent with closer analysis and the attribution of the associated barriers and building blocks to the overarching barrier of a lock-in, which show the consequences of the locked-in system that in turn are referred to as barriers far more frequently throughout the interviews than the initial response would suggest. This could be explained through the lock-in itself that the whole system is so aligned with the prevalent approach to flood risk. Therefore, the barriers that arise from it are rather referred to implicitly, instead of explicitly confronting the status-quo.

Additionally, both interviewees from the municipality represent a minority that consents with this barrier from the beginning, which in combination with the prior mentioned indicators speaks for this barrier as actors on the second layer can logically be expected to experience the barrier more, especially compared to the locked-in layer one. Also, the divergent perspective from the only stakeholder from the unembanked parts of Rotterdam (Interview_4) and the fact that most barriers are not experienced in that area, supports the significant influence of layer one protection for the implementation process of MLS.

When referring to the balance and integration of resistance and fluency, or in the threefold conceptualization of FR (Restemeyer, et al., 2015) discussed in chapter two: robustness, adaptability, and transformability, the data about the barrier of a lock-in suggests a challenging situation for the case of Rotterdam, because the level of robustness impedes the other components through binding resources, reducing urgency, and institutional advantages.

In this way the data brings new insights to the discussion about the role of robustness for FR by adding findings about the lock-in barrier within the implementation process of MLS to discussions with an ecosystem-based focus (Douven, et al., 2012) and a risk focus (Liao, 2014). Accordingly, to achieve FR the starting position matters, which seems to be a favorable one for MLS in the unembanked areas and needs consistent support through binding regulation and appropriate resources and capacity in the embanked areas that are affected by the lock-in.

### 4.1.3 Associated barriers (AB) with OAB I/II

Further barriers were identified already in chapter two (box 3) and throughout the interviews (figure 8), which refer and contribute to both overarching barriers (OAB I/OAB II) and are summarized as the associated barriers **'financial resources' (AB9 I/II)** and **'lack of acting capacity' (AB10 I/II)**. Below, it is explored in more detail to what extent interviewees recognized or rejected these and how they are experienced.

The barrier of **'financial resources' (AB9 I/II)** revolves around funding schemes, budget allocation, and the general financing approach. That current funding schemes and budgets are a barrier for the implementation of MLS finds ample consent in the interviews. All interviewees from the Municipality of Rotterdam (Interview_1, 11), the Safety Region (Interview_5, 6, 8), as well as from the Delta Program (Interview_3) and airport (Interview_7) agree with this barrier.

One part of this barrier refers to the distribution of money across the layers and actors. It is mentioned that if the MLS approach should be implemented on a larger scale, changes are necessary in how the money is distributed (Interview_1). Currently, the first layer is funded through national budgets that are constant and reliable, while investments in the other layers fall short (Interview_1, 5, 6, 10). This building block clearly relates to the OAB II as it is about the contemporary funding gap that privileges first layer investments and by that continuously expands protection and reinforces the lock-in.

Also, the lack of specialized funds is mentioned. Interviewee_2 sees a barrier in funding when different budgets are needed "and there is one lacking and when you need a lot of funds, and it does not exist" (Interview_2). At the same time there does not seem to be a problem due to the national water safety funds available (Interview_2). This shows again on the one hand the lock-in as first layer actors do not lack funding and on the other hand it refers to the OAB I as it covers the combination of budgets.

Additionally, interviewee_3 brings up the point of flexibility of budget allocation: “a lot of money is designated in certain budgets” (Interview_3). Once allocated, it would be hard to change the destination of the funding or transfer the money to another (layer 2 or 3) project.

The integration of private investments especially related to the implementation of the second layer of MLS is also a part of this associated barrier. The concentration on profits and different governance structures compared to the governmental bodies are experienced as difficult (Interview_3). Also, flood adaptation measures in the urban sphere that cannot produce a return on investment like housing or commercial buildings do by rent for example, would face an even stronger barrier in that regard (Interview_10). This building block relates distinctly to the OAB I as it combines the financial aspects with the fragmented objectives and procedures.

Finally, Interviewee_1 mentions that the implementation of MLS would currently not be cost-efficient following a cost-benefit analysis, which would make it hard to implement additional measures, especially in the poldered areas (Interview_1). However, a differentiation is made by Interviewee_6 from the Safety Region between the costs for implementing measures and the costs that would be caused by the consequences of a dike overtopping or breaching for example. To find the balance in calculating the costs for MLS is experienced as difficult in the light of climate change impacts (Interview_6). Nevertheless, the extra costs in combination with a low probability of the risk and no obligation, hamper the implementation of MLS (Interview_5). Furthermore, it is commented that especially for investing in consequence-reducing measures for extreme flooding scenarios, the uncertainty about the occurrence of such events questions how these investments can be justified at this moment (Interview_9). The general idea of additional flood safety is carried by all parties, but when it comes to financing integrated approaches, “no one wants to pay for it in the end” (Interview_7).

Referring to the second chapter, how the financial resources are set up in the form of funding and budgets is also recognized as a barrier for MLS in literature. Therefore, the combination of funds from different sectors and the focus on profits in planning processes are explicitly mentioned in line with this barrier (van Herk, et al., 2011; van Herk, et al., 2014). Additionally, the contemporary financing structures of flood management would hinder MLS (Hegger, et al., 2014; van Herk, et al., 2014).

The barrier of a **‘lack of acting capacity’ (AB10 I/II)** covers mainly the capacity of knowledge and experience as well as the availability of personnel to implement MLS. Six interviewees rejected this condition, while two acknowledged it with the rest not conveying a clear pro or con position. A reason why it was rejected is that the level of knowledge would be sufficient (Interview_3, 4, 6, 7, 10), but it would rather be a matter of understanding and using the knowledge that is there (Interview_5, 10), which refers to the OAB I and the lacking transfer of knowledge between the layers and is also discussed in literature in the context of a lacking mutual understanding of the effect of alternative measures (van Herk, et al., 2015).

The few consensual comments (Interview_1, 4, 8, 11), mostly refer to a lack of knowledge outside the groups of people that are traditionally dealing with flood management (Interview_4) or those who are newly integrated through an MLS approach. According to this, Interviewee_11 experienced a lack of knowledge about the sea-related water systems when starting to work on climate adaptation in Rotterdam. This is assumed to be the case for other colleagues in layer 2 as well (Interview_11). Accordingly, there would be "just a few people who understand FRM in a big city as Rotterdam" (Interview_1) and that there would be a shortage of "strategic employees" on the municipal level (Interview_11) to integrate flood risk to all layers. These comments confirm prior research by van Herk et. al (2011) that identified "limited experience with incorporating flood risk as a planning variable" (p. 307) causing "a lack of capacity among many professionals" (p. 307).

Another point raised within this barrier is about alternative measures that might be overlooked due to the general idea of "keeping water outside" (Interview_4) and "sometimes people do not know other possibilities than raising" and are not aware of possible alternative combinations and measures (Interview_1), which clearly links to the OAB II and the lock-in of protective measures.

Finally, a lack of knowledge is linked to a lack of experience mainly focusing on the third layer. Thus, only few people would have experienced serious flooding, which could cause uncertainty about what to do when a real disaster strikes (Interview_6, 8).

### 4.1.4 Additional barriers (AddB)

Some additional barriers are identified that are more general and not directly associated with the overarching barriers. The first one is about **'uncertainties' (addB1)** mostly regarding the future flood risk and its consequences. For all three representatives of the Safety Region such uncertainties are not a barrier for implementing MLS (Interview_5, 6, 8). This is reasoned with the visible climate change impacts (Interview_8) and an amount of certainty from the scientific predictions that would be sufficient to act (Interview_6). The comment by Interviewee_3 summarizes this reasoning that despite the uncertainty of what and when exactly, it just says something "about the speed of adaptation, but not the need of adaptation" (Interview_3).

An point in favor of this barrier is about the argumentation regarding "consequence-limiting measures and especially in the case of measures that are intended for extreme situations in the distant future, it is not always possible to say with certainty at this moment whether that money is being spent justly" (Interview_9). According to that, "nobody wants to pay for something he is not sure about" (Interview_2), which would even add up to the general problem of investing in water safety due to the low probability of an incident (Interview_2). In line with that, the uncertainty would become a barrier for implementation on project-scale, "because it is about money then" (Interview_1).

Furthermore, the scenario predictions that are used for FRM would be set on specific expected heights and put into policies, even though the projections increase constantly (Interview_11). In line with that, the flood maps for the local context of Rotterdam would be outdated (Interview_1). Accordingly, these maps of water coverage and flow in the case of dike breaches or failure are “already 15 years old” for that area, which would be too old for the implementation of MLS measures on project scale (Interview_1). Additionally, there is a high diversity of flood scenario maps and predictions from various private providers as well as changing public guidelines, which leads to confusion and unclarity about which scenarios to base on (Interview_5, 6). Consequently, there are multiple issues linked to uncertainties about the development of flood risk, which is also identified as a barrier in literature (box3) (van Herk, et al., 2011).

The next additional barrier is ‘**political barriers’ (addB2)** and refers to how the implementation of MLS is hampered by lacking dedication and lip service, and the focus on short-term issues within the legislative terms of politicians (Interview_5, 8). This is exemplified by labeling new projects as climate adaptive and agreeing to the relevance of IFRM without following through with this support in terms of concrete means (Interview_5). Also, it is mentioned that “politicians are looking four years ahead and that’s it” (Interview_8). Finally, the inertia of large-scale implementation of governmental decisions is brought up by the example of the decisions taken after the big flooding in 1953, which took “50 years to implement” (Interview_8). Such inertia of governmental bodies in decision-making is also discussed and confirmed in literature (Ritchie, 2014) even though seemingly not in the specific context of FRM.

Finally, the last additional barrier is about MLS implementation becoming **‘more complicated and expensive’ (addB3)** with time. From the outer dike perspective, Interviewee_4 sees this as a risk for future implementation of MLS, when increasing flood risk possibly complicates the process or it might be too late to implement certain measures (Interview_4). Thus, with increasing flood risk due to potential intensifications of climate change projections and scenarios, the preservation of the current water safety levels through the implementation of MLS measures would become more difficult in the form of reduced number of measures that are possible and increasing costs (Interview_4).

## 4.2 Opportunities for the implementation of MLS

SQ4.2: Are the identified opportunities also recognized in the practice of implementing MLS?
SQ6: What are additional opportunities that are experienced or expected by practitioners?

Based on the opportunities for the implementation of MLS (box 4), table 5 illustrates consent or dissent of the interviewed experts from practice with these opportunities. Whenever a cell shows an ‘N’ (no), the interviewee dissents with the opportunity being experienced or expected in practice. Whenever the cell shows a ‘Y’ (yes), the interviewee consents with the opportunity. The ‘?’ represents an indecisive opinion, the ‘-‘ no attributable answer, and ‘Y/N’ represents arguments for and against the opportunity. The columns (O1-O4) refer to the opportunities identified and discussed in the second chapter.

*Table 5. Interviewees consent/dissent with deductive opportunities (by author)*

| Interviewees | Stakeholder | O1 | O2 | O3 | O4 |
|---|---|---|---|---|---|
| Vera Konings (1) | Municipality | Y | - | N | Y |
| Marlies van der Maarel (11) | Municipality | Y/N | Y | Y | Y |
| Geanne Vink (5) | Safety Region | Y | Y/N | Y | Y |
| Mark Schipper (6) | Safety Region | - | - | - | - |
| Jacob Seen (8) | Safety Region | Y | - | ? | Y |
| Arie de Gelder (2) | Water Board | N | ? | ? | Y |
| Mark Flanagan (10) | Water Board | Y/N | Y | ? | Y |
| ○ (9) | Water Board | Y | Y | ? | Y |
| Steven van der Kleij (7) | Airport | N | Y/N | Y/N | Y |
| Robert Ranke (4) | Port (unembanked) | - | Y | - | - |
| Pieter Jacobs (3) | Delta Programme/RWS | Y/N | Y/N | Y | Y |

The following figure 9 shows the opportunities for the implementation of MLS in Rotterdam that are the result of the inductive questioning during the interviews. The numbers relate to the amount of phrases that are related to the respective opportunities throughout all eleven interviews.

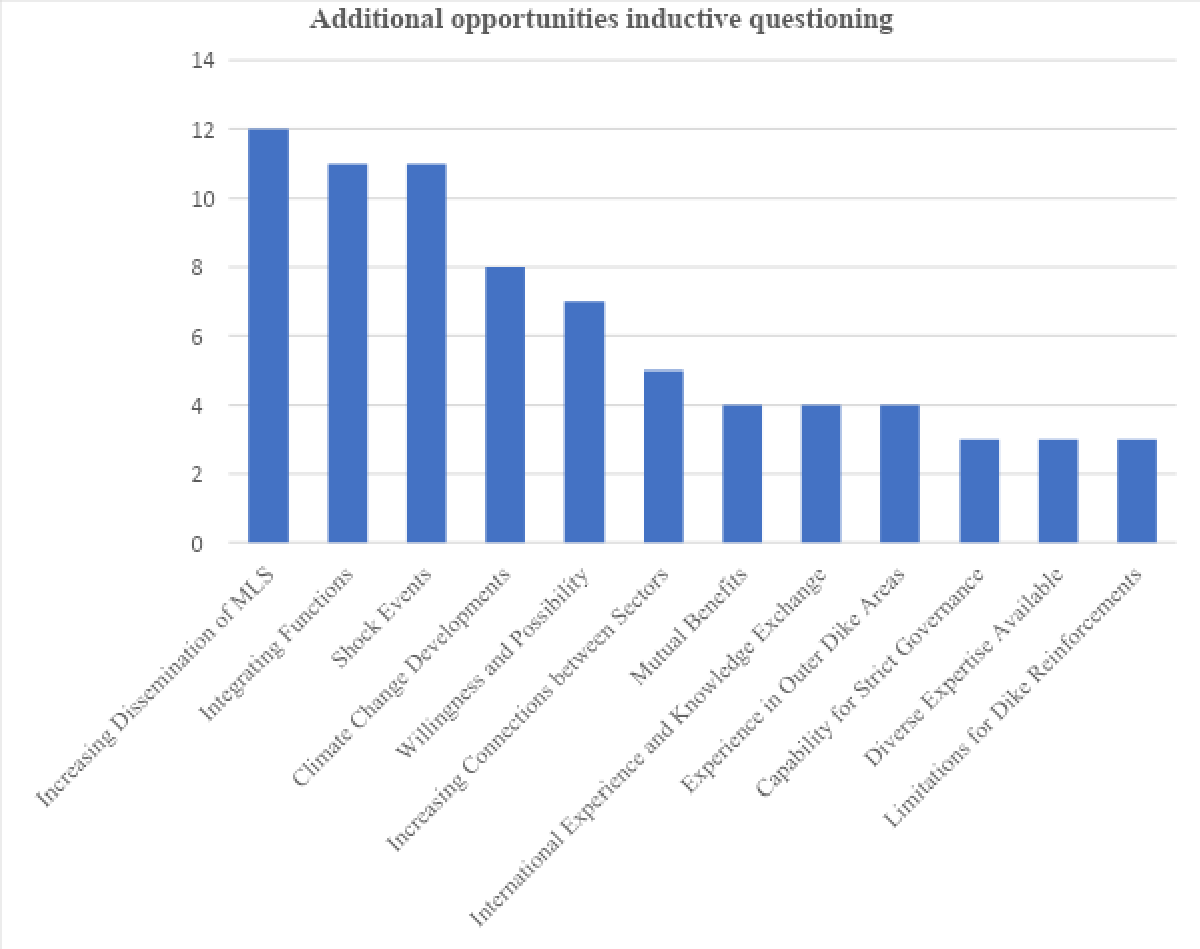


*Figure 9. Numbers of coded phrases about additional opportunities from inductive questioning (by author)*

The analysis of the data about the opportunities resulted in a slightly different structure compared to the barriers, in a way that the data about the opportunities suggests several categories instead of overarching phenomena. Thus, the opportunities are structured in four overarching categories that each include multiple associated opportunities that feed into the overarching category. According to that, it is structured as following: **Category I - pressures (CI)** with four opportunities **(CI O1-O4)**; **category II - mutual benefits (CII)** with three opportunities **(CII O5-O7)**; **category III - MLS in motion (CIII)** with two opportunities **(CIII O8-O9)**; and **category IV - available expertise (CIV)** with another two opportunities **(CIV O10-O11)**.

### 4.2.1 Opportunity category I - pressures (CI)

This first category might seem contradictory but literature and data from this study suggest that pressures on the status quo also contain opportunities for change or alternative approaches like in this case for the implementation of MLS. Therefore, the first opportunity within the category of pressures is about **'climate change impacts and socio-economic developments' (CI O1)**, which was introduced in the second chapter already (box 4). All interviewees that comment on the respective deductive question agree with this opportunity (Interview 1, 2, 3, 5, 7, 8, 9, 10, 11). Accordingly, the combination of the already experienced impacts of climate change would be urging more integrated approaches, in which "the MLS approach plays a central role" (Interview 3). In line with that, the attention for climate change adaptation that results from the impacts, scientific publications, and public discourse could be utilized to foster the implementation of MLS (Interview 1, 6, 8, 11) and would act as a common thread to bring together different sectors (Interview 1, 6). Also, it would drive acceptance for additional measures and foster formal pressure to adapt and mitigate (Interview 5). Especially for the highly urbanized and low-lying Randstad region the combination of climate change and urban development would be very relevant (Interview 7). What would also result from such pressures is that an integrated flood risk approach like MLS is considered inevitable at some point and "if you don't do it now, you have to do it in the future, and it will cost more money" (Interview 3).

This opportunity is also supported in literature as "the likely impacts of climate change in combination with socio-economic developments call for proactive and innovative plans" (p. 52 (Ritzema & Van Loon Steensma, 2018)) referring to expanding to a risk approach that also takes possible consequences into account.

The next opportunity is seen in '**shock events' (CI O2)**, which is closely linked to the previous one. It is mentioned that to support the implementation of MLS, the effects of climate change and socio-economic developments need to be experienced as "real facts instead of only scenarios for the future" (Interview 2). Accordingly, the increasing emergence of intense weather like heavy rain or draughts and the recent floods in Limburg would create momentum to implement an approach like MLS (Interview 8, 9) and acts as a trigger for more awareness for the issue of flooding and for more willingness to invest in extra measures (Interview 1, 2, 3, 5, 7, 8). In line with that, shock events are also discussed in literature as incidents that can create "windows of opportunity" (p. 1 (Kaufmann, et al., 2016)) in which change can be implemented.

The third opportunity in this category is the '**limitation for layer 1' (CI O3)**. This is due to comments about issues that arise for the flood protection system of Rotterdam. Accordingly, multi-functional development of dikes complicates reinforcement and maintenance (Interview 10). Also, in some areas the urban tissue would simply not leave room to reinforce the dike line (Interview 3) as a dike needs to expand in width as well when heightened. Therefore, such challenges for the first layer create a possible opportunity to focus on a combination of all layers.

The last opportunity in the category is the '**formal pressure through supranational governance' (CI O4)** that was already touched upon in chapter two. Thus, the respective EU directive would push "the member states toward integration of water management into spatial planning" (p. 2 (Bosoni, et al., 2021)). Four interviewees acknowledge this opportunity (Interview 1, 5, 8, 9) while two rejected it (Interview 2, 7). Interviewee3 supports this, but also acknowledges that the current EU Floods Directive leaves too much leeway for the implementation in the member states, "so countries can still put a lot of emphasis on prevention measures, do a little bit of layer two and three on the side and claim that this is a set of integrated measures". In line with that, this pressure would rather function as "a little nudge" (Interview 10), also in the Netherlands. Most interviewees did not consider this opportunity particularly relevant for the Netherlands, but rather for countries that are starting to grow in the field of FRM.

However, some dissent about this condition was also present for two reasons. Thus, interviewee2 and 7 argue that "we are quite aware of flood risk throughout the ages" (Interview 7) and that "international laws are less important because of the strict laws on flood protection in the Netherlands" (Interview 2).

### 4.2.2 Opportunity category II - mutual benefits (CII)

The second category of opportunities covers mutual benefits for the actors involved as well as the combination of different objectives, which could foster the implementation of MSL. The first opportunity within this category is '**integrating functions' (CII O5)** of FRM measures. This is expressed for layer three measures like emergency shelters that could be of help for any disaster besides flooding incidents (Interview 1). Furthermore, the 'Room for the River' program is mentioned as an example for a successful combination of flood safety, spatial quality improvement, and nature rehabilitation (Interview 3). In the context of scarce space in the urban area of Rotterdam, the possibility of integrated functions would be an opportunity to cover different combinations like spatial development and flood adaptation, but also climate change adaptation in general including heat stress (Interview 3, 11). Such possibilities can be supportive to convince individual actors to get on board with the MLS approach (Interview 5). A legislative opportunity in that regard is an amendment to rules relevant for water safety and spatial planning that has been recently discussed in the Dutch Parliament, "that in each project cooperation with other organizations that want something with the same area, but for other reasons than flood protection, has to be taken into account" (Interview 3). Interviewee11 mentions that such an integration of stakeholders and of different functions of space and infrastructure would create the "best solutions for society" (Interview 11). This is also referred to with the example of the mutual gains approach by the Delfland water board: "by working together you can actually get a better result" (Interview 10). Additionally, interviewee11 adds: "by designing with focus on water problems, we could connect other aims in a very positive way" (Interview 11), which underlines the possibility of integrating different functions as an opportunity for the implementation of MLS.

Closely linked to that is the next opportunity of '**more efficient FRM' (CII O6)**. While none of the interviewees clearly reject this opportunity, four explicitly agree with it (Interview_4, 9, 10, 11) and four remain indecisive or respond arguing for and against it (Interview_2, 3, 5, 7). Interviewee_10 brings up the example of adapting to pluvial flooding in low lying areas behind the dike to be able "to hold that water in the lower polder, so it doesn't need to be pumped up immediately during peak rain events" (Interview_10), which would make it more energy efficient in a certain context. Furthermore, at least for unembanked areas financial efficiency is mentioned as: "So, what you see with the MLS approach looking at wet proofing and dry proofing, it sometimes makes it accessible for a lot of different stakeholders." (Interview_4). Thus, MLS would offer the opportunity of increasing "the safety of your area with low impact measures" (Interview_4). Interviewee3 sees an opportunity for MLS in more efficient FRM, if different functions are combined, like public spaces that can hold rainwater or multi-functional dikes (Interview_3). With a special focus on financial efficiency, he sees it more as a long-term opportunity for when the prevention paradigm cannot cope with the sea level rise anymore (Interview_3). But right now, the investments in the first layer flood protection system are seen as more efficient in the Netherlands (Interview_2, 3).

Even though the data only includes one interviewee from an unembanked area, the statements about efficiency seem to depend on the different local contexts in Rotterdam in terms of inside and outside the dike when taking results about second layer measures in the unembanked areas of Rotterdam into account (de Moel, et al., 2014). The data as well as findings in literature do not suggest a generalization about cost-efficiency of MLS as statements in that regard depend on multiple factors like among others the specific measures, the locality, the discounted consequences of potential flooding (Hoss, et al., 2013).

Finally, the last opportunity of this category is about '**higher acceptance and legitimacy' (CII O7)**. The opportunity is agreed upon by interviewees_3, 5, and 11, while most remain rather indecisive. Still, it would be a crucial opportunity, as "public acceptance and political acceptance is what you need to get the job done" (Interview_5). It relates especially to "the combination of layers 1 and 2, which provides opportunities of spatial development to result in a higher quality of the build environment than investment in prevention measures alone" (Interview_3). Such combinations could foster the implementation of MLS compared to quite a lot of resistance that is experienced against the reinforcement of dikes despite being backed by regulations and laws (Interview_10). Concluding, the interviewed practitioners ascribe certain importance to the acceptance of FRM measures, which seems to be the case with MLS according to positive results that are observed in a case study about Dordrecht (van Herk, et al., 2014).

### 4.2.3 Opportunity category III - MLS in motion (CIII)

The third category of opportunities MLS in motion includes a few opportunities that arise from the institutional situation of growing importance of and capacity for the implementation of MLS. The first one is the '**increasing dissemination of MLS' (CIII O8)**. Accordingly, various interviewees mention a shift towards more awareness of integrating the second and third layer throughout the governmental actors and describe an increasing dissemination especially of the relevance of spatial adaptation (Interview_1, 2, 3, 5, 10). The MLS approach is a central element of different programs and policies, like the Delta Programme (Interview_1, 2, 3). Different current administrative developments might further push MLS on the national (Interview_3) and local level of Rotterdam (Interview_9). Additionally, there would be a certain readiness to incorporate diverse measures of MLS by different private actors as well (Interview_4, 7). This trend is also recognized in academia (Hegger, et al., 2016) and lines up in the ongoing discussion of a paradigm shift in literature (Ritzema & Van Loon Steensma, 2018; Restemeyer, et al., 2015) that is abundantly referred to throughout the second chapter.

The second opportunity also relates to the contemporary development of how water is managed and is seen in '**increasing connections between sectors' (CIII O9)**. This is mentioned with regards to individuals as boundary-spanners that connect the sectors by transferring their knowledge and experience. Examples are about bringing climate adaptation expertise to the various projects the municipality is involved with (Interview_1), and a partly dual employment of disaster management experts in the water boards and the safety region to increase cooperation between the organizations (Interview_8). It is commented that compared to the past the connection and cooperation between the sectors in the context of FRM generally increased and would be on a good way, which is vital for the implementation of MLS (Interview_6, 8). A potentially important role for the integration of different sectors is also acknowledged in literature (Warner, et al., 2010).

### 4.2.4 Opportunity category IV - available expertise (CIV)

The last category covers opportunities emerging from available expertise of relevance for the implementation of MLS. The first one is **international experience and knowledge exchange (CIV O10)**, which is mentioned about looking into examples outside the Netherlands that provide insights about possible solutions as well as approaches that did not work out well, to foster local implementation of MLS (Interview_3). Due to the contextual nature of flood risk such experience can indeed not just be copied, but provides relevant lessons learned. Also, the international practice of Dutch companies in the field of flood management would help by broadening the scope and experiencing different perspectives and contexts (Interview_2). Such transfer and international application of Dutch water expertise finds ample documentation in literature (Hasan, et al., 2019; Hasan, et al., 2020). Finally, interviewee_7 mentions the 'Rotterdam-The Hague emergency airport project', which was planned as an emergency airport and shelter in line with the MLS approach. The project additionally involved the possibility of the airport serving as a United Nations emergency airport hub for international humanitarian assistance (Interview_7), which suggests international cooperation for individual projects as a promotion of MLS.

The final opportunity for the implementation of MLS is the **local capabilities and experience (CIV O11)** that is available regarding FRM. Thus, Dutch expertise about flood management would spread through various sectors and actors, which would create a "very good basis for joint finding of more-layered safety" (Interview_9). Furthermore, it is emphasized that the differences in focus of the various sectors create a valuable bundle of expertise for the implementation of MLS if utilized (Interview_5). Additionally, there is already significant experience with MLS in Rotterdam, especially in the unembanked areas, which could foster the implementation elsewhere in the city (Interview_1, 4). Lastly, the governing style in the Netherlands is considered capable of adopting the MLS approach, referring to the continuous consideration and reflection about the regulations (Interview_10), and would also have the means to get private actors to go along with the implementation of MLS measures (Interview_3).

### 4.2.5 Reflecting on the categories and opportunities

The data shows that there are ample opportunities that can foster the implementation of MLS and can be utilized along the process. Regarding the category of pressures (CI), the emphasis on the threefold conceptualization of FR (Restemeyer, et al., 2015) and an evolutionary resilience understanding (Davoudi, 2012) seems essential in order to embrace and utilize the pressures as opportunities instead of resisting to maintain an elusive equilibrium like assumed in the earlier forms of resilience. To try to maintain the status quo or bounce-back after a flooding scenario would hinder the evaluation of such pressures as opportunities. These mostly external pressures from the outer context that affect the inner setting of contemporary flood management through limitations for protective layer one measures, relate well to Damschroder et. al (2009) about the CFIR: "changes in the outer setting can influence implementation, often mediated through changes in the inner setting" (p. 5).

For the mutual benefits category (CII), the consolidation of opportunities reflects the theoretical advantages of the MLS approach like reduced flood risk through effective combinations of measures from all layers. Therefore, these opportunities can be seen as incentives in form of a normative goal to achieve rather than concrete opportunities to utilize. Especially in comparison with the overarching barrier sectoral fragmentation and its various building blocks and associated barriers that all hinder the process of achieving such mutual benefits, the fostering impact of these opportunities could be reduced. But the more these advantages are experienced and forced upon the actors due to the pressures for example, it can be expected that the advantages get more popular.

The next category of MLS in motion (CIII) refers well to the general ongoing paradigm shift and a change of how things are done in flood management (Ritzema & Van Loon Steensma, 2018; Restemeyer, et al., 2015). The MLS approach cascading through the different sectors that are to be involved with MLS counters sectoral fragmentation. Referring to the CFIR (Damschroder, et al., 2009), these opportunities are largely based in the inner setting and shaped by individuals that "have agency; make choices and can wield power and influence" (p. 5 (ibid.)) acting as boundary-spanners.

Finally, the category available expertise (CIV) and the opportunities seem to be very much shaped by the contemporary flood management and planning system in the Netherlands, which is certainly one with plenty of expertise in such topics, but runs the risk of creating a techno-institutional lock-in. When dismissing the former concept of an equilibrium characterized by stability to resist stress (Davoudi, 2012) and moving beyond this idea towards FR in an evolutionary form, certain fundamental assumptions in contemporary water management of controlling water need reconsideration.

## 4.3 Reflecting on the conceptual model

Based on the conceptual model (figure 6) in the second chapter (2.6), the analysis of the data results in a few additions to the initial model. Figure 10 still includes the basic structure of FR and MLS as the main concepts. In between the messiness and ongoing back and forth throughout the implementation process is illustrated by the feedback loops. The barriers and opportunities impact the implementation in various ways. Thus, sectoral fragmentation and techno-institutional lock-in are the two overarching barriers whose blocking effect on the three components of FR as the normative goal are illustrated through the black arrows. In between both overarching barriers the associated and additional barriers are illustrated and complete the barriers identified in this study. The opportunities on the other hand include the four identified categories in a funnel-like shape narrowing from the rather general and external pressures towards more concrete conditions specific to MLS that can foster the implementation.

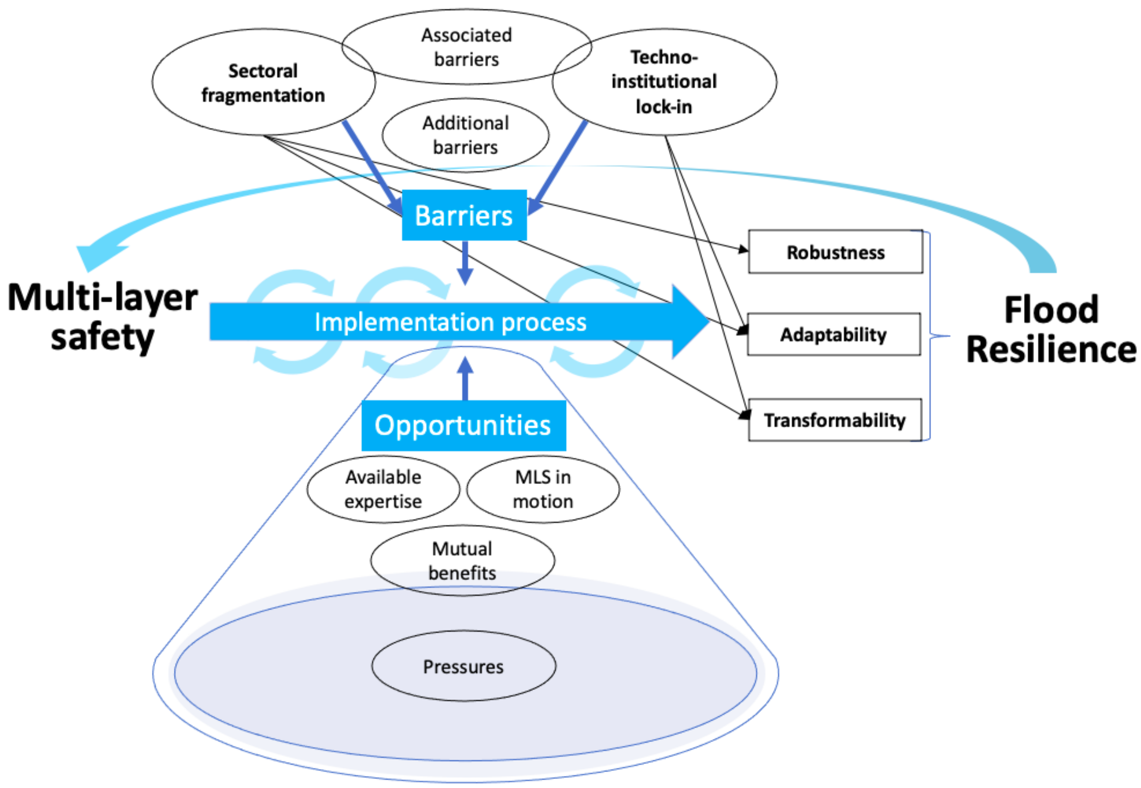


*Figure 10. Updated conceptual model (by author)*

# 5. Conclusion

The central aim of this thesis is to identify barriers and opportunities for the implementation of MLS in an urban context and to study the MLS approach as an operationalization of the FR concept. The main research question is: *What are the barriers and opportunities for the implementation of urban multi-layer safety to increase flood resilience?*. To answer this question, literature regarding FR and the MLS approach were brought into connection with implementation theory, which together got depicted in a conceptual model. The theory was used to identify certain barriers and opportunities in literature. The theoretical framework informed the ensuing qualitative data-collection of conducting 11 semi-structured interviews with experts covering the different layers of MLS by the single-case study example of Rotterdam. The following figure 11 summarizes the barriers and opportunities for the implementation of MLS, as identified in this study and can be understood as the illustrated answer to the main research question.

**Barriers**

OAB I (overarching barrier I) – sectoral fragmentation
- barriers associated with OAB I
  - AB1 I – number of actors
  - AB2 I – long-term vs. short-term
  - AB3 I – scaling
  - AB4 I – limited space
  - AB5 I – competition with other threats
  - AB6 I – policy integration

OAB II (overarching barrier II) – techno-institutional lock-in
- barriers associated with OAB II
  - AB7 II – lack of urgency/levee effect
  - AB8 II – lack of regulatory framework
- Barrier associated with OAB I and OAB II
  - AB9 I/II– financial resources
  - AB10 I/II – lack of acting capacity

AddB (additional barriers)
- AddB1 –Uncertainty
- AddB2 – political barriers
- AddB4 – more complicated and expensive with time

**Opportunities**

CI (category I) – pressures
- CI O1 – climate change impacts and socio-economic development
- CI O2 – shock events
- CI O3 – limitations for layer 1
- CI O4 – formal pressure through supranational institutions

CII (category II)– mutual benefits
- CII O5 – integrating functions
- CII O6 – more efficient FRM
- CII O7 – higher acceptance and legitimacy

CIII (category III) – MLS in motion
- CIII O8 – increasing dissemination of MLS
- CIII O9 – increasing connections between the sectors

CIV (category IV) – available expertise
- CIV 10 – international experience and knowledge exchange
- CIV 11 – local capabilities and experience
- CIV 12 – capability for strict governance

*Figure 11. Final overview of barriers and opportunities for the implementation of MLS (by author)*

This study offers insights on the implementation of the MLS approach in an urban context gained through detailed research on the case study of Rotterdam. The identified barriers and opportunities represent a broad overview of issues that inform about what hinders the implementation of MLS, and what can foster the implementation and could be utilized to move towards FR.

The interviews emphasize that most barriers are associated with the two overarching barriers sectoral fragmentation and techno-institutional lock-in, which suggests significant challenges as these barriers seem antagonistic to the core components of MLS and FR. Even though Rotterdam is considered a frontrunner in climate change adaptation and spatial planning (Eraydin & Taşan-Kok, 2013), the data as well as literature (Wesselink, et al., 2015) suggest that the paradigm shift in flood management is not accomplished yet in the Dutch context, where the established approach of technical flood protection still prevails in the presence of such barriers. Due to this high level of flood protection, the context of the noticed distinction between the implementation of MLS in unembanked and embanked areas acknowledged in literature (Hoss, et al., 2013; de Moel, et al., 2014) and this study's data, a high relevance of the starting point for FR is suggested.

Regarding the opportunities, the results show the advantageous core components (section 2.3) of the MLS approach in a time of multiple pressures exerting on the local context that demand more adaptability and transformability from flood management. While the interviews show changes in water management towards an integrated risk approach is seemingly happening, the data as well as the identified opportunities in literature (box. 5) show an underrepresentation of the opportunities compared to the barriers. In the context of the category available expertise there can be a potential risk of the lock-in barrier manifesting in the opportunities. Nevertheless, it becomes clear that boundary spanners can play a central role to foster integration and create capacity to adapt and transform, in which planners can be of use. The opportunity category of pressures is without doubt significant and it remains open if a shift can work out incrementally against the barriers or if a swift disruption of the systems' structure and function forces a transformation at some point.

## 5.1 The insights this study delivers

Compared to previous studies, the opportunities and barriers are at the core of this research and therefore not just a byproduct of a specific case studied. As such, this study adds value to FRM academia through a holistic overview of the opportunities and barriers for implementing the MLS approach as an operationalization on the way towards FR reflecting actors from all three layers in the specific context of Rotterdam. Thereby, the results also provide more insights on the feasibility and relevance for achieving FR and contribute to specifying the concept of resilience and its rather vague character. Additionally, through this study and the broad coverage of opportunities and barriers, various topics of research like lock-in, fragmentation, transitions, policy integration, and urban design that are widely discussed in planning research are empirically supported to be essential within the implementation of MLS and the endeavor to increase FR.

As for planning practice, the results provide insights for actors involved with the different layers of MLS about new perspectives on FRM and could potentially help to reduce sectoral fragmentation by itself, as it can lead to better understanding among these actors to integrate the layers. Additionally, through the connection of MLS and FR, the research can contribute to a more consistent understanding of what FR entails on an operational level. Furthermore, the compilation of opportunities and barriers suggests both: 1) specific starting points of which barriers need to be tackled and 2) opportunities that can be utilized to better adapt to the climate crisis in terms of hydrological hazards in Rotterdam, and more general issues that influence the implementation process at a higher level.

## 5.2 Reflections

**Theoretical reflection**

Even though various practical insights for the implementation of MLS to achieve FR can be derived from the results, they turn out to be positioned mostly rather on a meso level, indeed with a detailed focus on the case study region and thereby offer a general picture of implementing the whole approach in a local urban context but come up short on barriers and opportunities in specific processes along the implementation. Thereby, the large scope of the opportunities and barriers goes along the limitation that for each individual opportunity and barrier the insights remain rather shallow. This also makes it difficult to study the opportunities and barriers in a more detailed way concerning implementation theory.

In general, the combination of the concepts of MLS and FR and framing of MLS as a way of operationalizing FR worked well but could have played a bigger role within the empirical part as well. In the context of the recurring phenomenon of a paradigm shift in flood management, it could also have been a relevant theoretical enrichment to add aspects of transition theory.

**Methodological reflection**

A methodological limitation of the thesis is the constraint to the case study area of Rotterdam, which could have been counteracted with a multiple-case study or two comparative case studies. Also, the selected interviewees fall short on representing private actors like project developers and architects that are essential to implement MLS as realizing the approach on project-level. Despite the detailed insights that were gained through the interviews, both factors limit the generalizable validity of the results. Additionally, for instance a systematic literature review of specific barriers and opportunities would have added value in terms of data triangulation.

Nevertheless, the high number of qualitative semi-structured interviews generated a substantial array of relevant data from multiple actors that represent all layers of the MLS approach. More interviewees from the outer dike areas of Rotterdam would have added even more empirical value, as this perspective is represented by just one interviewee.

**Reflection on the research process**

The research process was long and tough attached to and following on a master program that was fundamentally characterized by the covid pandemic causing mental and physical strain. As a result, essential exchange especially in the early steps of the research was barely possible, which additionally aggravated the process. The data collection phase ended up stretching throughout various simultaneous research phases, due to the dependence on third parties' response and cooperation in the form of acquiring interviewees. However, a reasonable number of interviews has been achieved. The technicalities in terms of conducting, recording, and analyzing the data worked well.

## 5.3 Suggestions for further research

Several suggestions for further research are derived from this study. First, a deeper understanding of the cooperation between governments and the private sector in the context of MLS is suggested. In this study, mostly (semi)governmental officials participated, while MLS generally requires the involvement of the private sector as well. Interviewee3 acknowledged this by stressing the importance of the cooperation between public and private actors in realizing MLS. Therefore, future research could focus on the cooperation between public private partnerships in the implementation of MLS.

Secondly, building on the overview of the barriers and opportunities identified in this research, future research could address strategies to cope with the barriers and to utilize the opportunities. While not covered in this thesis, it would be a valuable addition to the results that can be followed up on and would aid the implementation of MLS. Still, it needs to be kept in mind that such strategies are highly contextual as are the specific measures within the MLS approach.

Lastly, as the results of this study imply an important role for the starting point to implement MLS and emphasize the special role of unembanked areas, more insights for the implementation of MLS in such areas can be of interest potentially in the form of comparative research.

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# Appendix

**Interview structure**

- Collecting basic information about the interviewee and starting off with an easy question to answer
    - What is your professional/educational background and what is your current position and function?
- Enquire attribution to the layers and responsibilities
    - How are you involved in flood risk management in Rotterdam and what are your responsibilities?
    - which layers of the multi-layer safety approach?
    - what about the whole organisation?
- Barriers for MLS implementation (inductive)
    - What barriers did you experience, or do you expect for the implementation of multi-layer safety in Rotterdam?
- Barriers for MLS implementation (deductive)

| | | |
|---|---|---|
| B1 | Sectoral fragmentation | |
| B2 | Techno-institutional lock-in | |
| B3 | Lack of knowledge | |
| B4 | High number of actors and stakeholders | |
| B5 | Differences in funding and budgeting | |
| B6 | Uncertainty about future flood risks | |
| B7 | Different planning periods (rather short-term/or long-term) | |

- Opportunities for MLS implementation (inductive)
    - What opportunities did you experience, or can you expect for the implementation of MLS in Rotterdam?
- Opportunities for MLS implementation (deductive)

| | | |
|---|---|---|
| O1 | More efficient flood risk management | |
| O2 | Higher acceptance and legitimacy | |
| O3 | Formal pressure through supranational institutions | |
| O4 | Climate change impacts and socio-economic developments | |

- Option for additional content
- Inquire more contacts
- Asking to provide the results of the thesis when it is finished