



THE 2021 FLOOD EVENT AS *WAKE-UP CALL* IN DUTCH FLOOD RISK MANAGEMENT

*Exploring if and how the 2021 flood event in Limburg triggered
policy change in Dutch flood risk management*

S.E. le Coq (Susanne)

Master's Thesis for the Spatial Planning programme,
specialisation Planning, Land & Real Estate

Nijmegen School of Management

Radboud University

November 2025

**The 2021 flood event as *wake-up call* in
Dutch flood risk management**

Colophon

The 2021 flood event as *wake-up call* in Dutch flood risk management

Exploring if and how the 2021 flood event in Limburg triggered policy change in Dutch flood risk management

Nijmegen, November 2025

Author

S.E. le Coq (Susanne) – s1145997

Supervisor

Dr. C. Vitale (Corinne) – Thesis supervisor Radboud University Nijmegen

First reader

Dr. C. Vitale (Corinne) – Radboud University Nijmegen

Second Reader

Dr. K. Kresse (Klaas) – Radboud University Nijmegen

Word count

± 22.500 words (excl. Front and Back material including the colophon, preface, abstract, keywords, summary table of contents, lists of tables, figures, and abbreviations, references, and appendices)

Cover image

A photograph of residents being transported through the high waters of the river Maas between Bergen (LB) and Nieuw Berge on the 19th of July 2025 (source: <https://nos.nl/artikel/2477228-draaiboek-en-adviesteam-voor-limburgse-buurtten-bij-extreme-wateroverlast>)

Radboud University



Preface

The choice of the flood event in Limburg in 2021 as the focus of my master's thesis originates in my interest of water management, and how it influences the spatial planning in such a small country with a relatively large surface of water as The Netherlands. Living in the Netherlands without water is therefore unthinkable, and it was precisely the dynamics between the advantages and disadvantages of this abundance of water that made me interested in exploring this tension, especially since The Netherlands is my country of origin. My focus was directed at the impact of such an event on flood risk management, since this shows how we act upon the growing disadvantages of water because of climate change.

This resulted in this master's thesis, titled *The 2021 flood event as wake-up call in Dutch flood risk management*, about the capability of this flooding event to trigger policy changes. First, I would like to express my gratitude for my supervisor, Dr. Corinne Vitale, who has provided me with structured guidance throughout the whole process of writing my thesis. In addition, I would like to thank all the interviewees that contributed to the data of this thesis, and deepened my understanding of the empirical case of the floods, and its institutional aftermath. Their involvement was critical for the completion of my thesis.

Susanne le Coq
Nijmegen, November 2025

Abstract

This thesis examines if the flood event of 2021 in the Dutch province of Limburg functions as an event triggering policy change in flood risk management, and how. Heavy rainfall in The Netherlands and its bordering countries caused exceptional levels of high water and floodings on a large geographical scope. This study uses factors of stability and change to assess whether and how this extreme event triggered the adaptation of existing policies and the adoption of new policies. Through incorporating policy documents and fifteen semi-structured interviews with different relevant actors, this study demonstrates the impact of the event and its consequences on the short- and long-term. This impact is studied in an institutional context, rather than a societal context. The results show that while post-flood evaluations underline the urgency for new approaches and mindsets, such as accepting certain risks instead of preventing all flood risks, the practical implication of these evaluations mainly include improving modelling systems and adopting existing programs. This lack of actual paradigm shifts suggests that, while Dutch flood risk management and its actors claim to become more climate change- and flood resilient, this resilience appears to be rather limited and not aimed towards adapting to future climate risks.

Keywords

Flood risk management, climate change, institutional analysis, spatial planning, shock event.

Summary

In July 2021, extreme rainfall across The Netherlands, Belgium, Luxembourg, and Germany caused exceptional water levels and consequential floodings. In the Dutch context, especially the province of Limburg was heavily affected. This flooding event underlines the urgency of counteracting climate change and global warming, as it is often framed as a *wake-up call* for flood risk management (FRM). However, this urgency does not mean that such events directly lead to policy change, due to possible stabilising factors exercising pressure on existing policy structures. This research aims to examine whether and how the 2021 flood event has triggered policy change in Dutch FRM, and FRM in Limburg. The main question guiding this research is: *'Did the July 2021 flood event in The Netherlands act as a shock event that triggered policy change in Dutch flood risk management and how?'*.

To answer this questions, this study combines a policy document analysis and fifteen semi-structured interviews in a qualitative case study research design. The interviews are conducted with relevant actors of different institutions such as ministries, Rijkswaterstaat, water boards, the province, research institutes, the crisis organisation, and a citizen based foundation, enabling an in-depth analysis across different perspectives and expertise.

This analysis shows that the exceptional character, and the material, societal, and financial damage of this flood event generated clear signals for change. Many of the interviewees and policy documents stress the need for rethinking our assumptions about rainfall and flood risks, especially the belief that all flood risks can be prevented. It is argued that this idea must shift into a focus on preparing for extremes as much as possible, since not all flood risks can be eliminated apparently. Many more similar debates arose, generating new ideas for future FRM. Examples entail preparing for multi-day rainfall sequences, strengthening self-reliance, and adjusting our spatial planning approach in order to keep the floodplains free to limit damage.

These shifts in mindset were followed by several procedural and technical adaptations within Dutch FRM. Water level modelling was updated, warning systems were improved in terms of coordination and communication, and the multi-layer safety approach was expanded through two new layers of water awareness and recovery. In addition, on the provincial level the governmentally funded WRL programme was established through a shared willingness of different institutions to collaborate in coordinating adaptive measures. However, the findings show that these shifts and programmes mostly remain within the existing FRM paradigm, as seen in the adaptations and improvements, rather than the establishment of new formalised policies. Path dependencies, accepted responsibilities, restrictive construction and insurance laws form stabilising factors hindering such change, and reinforce the familiar measures focused on physical resilience rather than new integrated measures focusing on adaptive resilience.

This leads to the main conclusion that although the 2021 flood event has stimulated evaluations, learning, and adjustments of policies, it did not yet trigger fundamental policy changes in Dutch FRM. Moreover, the timing of this research could be an explanatory factor for this conclusion, since some formal policy programmes, such as the Delta Programme, are not renewed since 2021 and did not have the chance to incorporate post-flood insights. Further research could also focus more on the stabilising factors, to better understand which conditions need to change in order to enable actual paradigm shifts.

Table of Contents

Colophon.....	2
Preface	3
Abstract.....	3
Keywords	3
Summary	4
Table of Contents	5
List of figures.....	8
List of tables	8
1. Introduction	9
1.1 Climate change	9
Global warming.....	9
Flood hazards	10
1.2 Problem statement and research aim	11
Problem statement	11
Research aim	14
1.3 Scientific relevance.....	14
1.4 Societal relevance	15
1.5 Outline of thesis.....	16
2. Theoretical framework	16
2.1 Climate change and climate change adaptation	16
Floods and flood risk	17
Flood risk management	18
Shock events.....	19
2.2 Stability and change in policy arrangements.....	20
Frameworks of forces of stability and change	20
2.3 Operationalisation	23
Conceptual model	24
3. Methodology	25
3.1 Research Philosophy	26
3.2 Approaches to theory development	27
3.3 Methodological choices	28
3.4 Research strategy	28
3.5 Case study selection	29

3.6 Time	29
3.7 Techniques and procedures	30
Data collection.....	30
Data analysis	33
3.8 Reliability, Replicability, and Validity.....	34
3.9 Ethics	34
4. Results.....	35
4.1 Shock event	35
Suddenness and unpredictability.....	35
(Possible) harm and magnitude	36
Institutional responses.....	38
4.2 Factors of change	42
Actors and coalitions.....	42
Resources and power.....	43
Rules of the game.....	44
Policy discourses	44
4.3 Factors of stability.....	46
Actors and coalitions.....	46
Resources and power.....	46
Rules of the game.....	47
Policy discourses	47
5. Discussion of the results.....	48
5.1 Policy reaction or policy silence?	48
5.2 Stability as a blessing or a curse	49
5.3 The missed opportunity of the <i>shock event</i>	49
5.4 The illusion of resilience	50
6. Conclusions.....	51
6.1 Sub-question 1.....	51
6.2 Sub-question 2.....	52
6.3 Sub-question 3.....	53
6.4 Sub-question 4.....	53
6.5 Answering the main research question.....	54
7. Reflection and further research	56
7.1 Reflections.....	56
Reflection on the research methods.....	56
Reflection on the theoretical framework.....	56

7.2 Recommendations	57
References.....	58
Appendices.....	64
Appendix 1: Interview Guide	64
Introduction	64
Policy change.....	64
Factors of change.....	64
Factors of stability.....	65
Lessons	65
Appendix 2: Atlas.ti Codebook.....	66

List of figures

Figure 1: Observed rainfall. Source: ECMWF (2021).

Figure 2: A map of the levels of discharge of the Maas-, and the Rijn River. Source: Copernicus (2021).

Figure 3: A map of the affected areas in the provinces of Limburg and Noord-Brabant. Source: Rijksoverheid (2021).

Figure 4: The tetrahedron of Liefferink (2006) of a policy arrangement.

Figure 5: The forces of stability and change framework of Wierink, Liefferink & Crabbé (2018)

Figure 6: Conceptual model. Source: own.

Figure 7: The research onion of Saunders et al. (2016). Source: Melnikovas (2018).

Figure 8: The spatial distribution of financial damage in euro's per 25x25 square meter along the Geuldal. Source: document 9.

Figure 9: The updated multi level safety approach. Source: document 1a.

List of tables

Table 1: operationalisation table. Source: own.

Table 2: List of policy documents. Source: own.

Table 3: List of semi-structured interviews. Source: own.

Table 4: The conceptualisation of the concept '*shock event*' into the indicators that were used to code in Atlas.ti. Source: own.

Table 5: Headlines of the 21 recommendations from the end report of the policy table from document 1a.

Table 6: The conceptualisation of the concept 'factors of change' into the indicators that were used to code in Atlas.ti. Source: own.

Table 7: The conceptualisation of the concept 'factors of stability' into the indicators that were used to code in Atlas.ti. Source: own.

1. Introduction

1.1 Climate change

Global warming

Before the 20th century, global warming happened at a slow rate since it was mostly caused by natural events. For example through volcano eruptions, where a lot of CO₂, a greenhouse gas, is emitted into the air. *“Greenhouse gases are those in the atmosphere that are essentially opaque to long-wave radiation but virtually transparent to short-wave radiation”* (Harris, 2010, p. 15). Those greenhouse gasses form the ozone layer, which keeps the earth warm. It allows the short-wave radiation to warm the earth, but keeps the reflecting long-wave radiation from escaping, causing the earth to warm up, which is called global warming.

Since 1950, humans are seen as the biggest contributor to global warming, instead of natural events. Mainly by causing air pollution through emissions of carbons and other substances like NO₂, generated by human activities such as using machinery and burning fossil fuels (Kousar et al., 2022). The greenhouse gasses that are emitted during these processes make the ozone layer thicker, capturing more warmth around the earth, causing the earth to warm up, causing climate change. There are *“...exponential curves of greenhouse gas concentrations, and temperature rise, and sea-level increase, and the rate of glacial melt”* (Gleick, 2010, p. 125). These curves can be linked to population growth, and infrastructure- and land-use changes (Manandhar et al., 2023). This process is causing our climates to change, effecting life on earth on a worldwide scale. The ecological impacts directly effect the planet, while also influencing the health and well-being of the population. The World Health Organization even named climate change *“the greatest threat to human health”* (Ziegler & Muchira, 2023, p. 646). This is happening more exponentially, making it an urgent problem.

A case study of the effects of climate change in Japan by Brimblecombe et al (2020) offers a representation of possible hazards effecting humans. Firstly, the heat caused by global warming, especially in cities, is discussed. Heat causes problems as urban heat islands, leading to health risks for the urban population. Secondly, glaciers and snow all over the globe are slowly melting because of global warming. This leads, amongst other things, to an increase of the sea-level at a rate of about 3mm each year (Hay et al., 2015, cited in Desmet et al., 2018), causing coastal floodings. In addition, the sea temperature rises, causing issues for the rich biodiversity of seas and oceans. Thirdly, intense rainfall as a consequence of climate change is discussed. In the following paragraphs the effects of heavy rainfall and consequential floods will be further discussed.

Flood hazards

“Water offers a good example of the challenges we face.” (Gleick, 2010, p. 126). The concepts of climate and water are linked within the climate cycle since the hydrologic cycle exists. For this reason, and as mentioned in the previous paragraph, sudden and extreme rainfall can be linked to climate change. “Climate change intensifies the water cycle and affects rainfall patterns, resulting in more intense rainfall and flooding [...]” (Manandhar et al., 2023, p. 2). Research has even shown that climate change makes heavy rainfall events 1.2 to 9 times more likely to happen (Tradowsky et al., 2023). Rainstorms are often sudden and intense, with much water coming down at once. This can cause rivers to overflow into urban and/or rural areas, especially in urban areas this can cause major damage. The demolition of the built area, the economic costs, the mental impact, and the environmental effects take a long time to be recovered. Examples are welfare losses, the displacement of the population, and dikes that are being broken. Furthermore, by looking at the impact these floodings have on their environment, it can be stated that “Floods are one of the most threatening natural hazards for human societies” (e.g. WBGU, 1999, cited in Schanze, Zeman & Marsalek, 2006, p. 1).

Within this paper, the focus is on river floodings caused by heavy rainfall, which is called a fluvial flood, because of the fact that the specific case of this study is a fluvial flood event. Some floodings can be considered ‘good for the environment’, for example in terms of restored nutrients and water supplies in this area (National Levee Database, n.d.). On the other hand, floods can also have unwanted negative effects, as mentioned above. What makes these consequences even more alarming is the fact that the flood frequency has significantly increased statistically over the last three decades, which can be linked to the previously discussed climate change (Najibi and Devineni, 2018). In total 4311 flood events have happened worldwide during those last three decades. Between 2001 and 2020, floodings even appeared to be the most common type of disasters caused by climate change. This is still increasing in terms of frequency, severity, and duration. Even when only focussing on the last few years, an alarming frequency of floods is visible. In October 2024, the floodings as a consequence of Storm Boris “Affected [the] countries [...] Spain, Austria, the Czech Republic, Croatia, Germany, Hungary, Italy, Poland, Romania, and Slovakia.” (CDP, 2024). Another example is the heavy rainfall of Storm Minerva in May 2023, inducing flood fatalities in Italy (Copernicus, 2023).

1.2 Problem statement and research aim

Problem statement

The 2021 flood event in the province of Limburg, caused by heavy rainfall, revealed weaknesses in Dutch flood risk management amidst rising climate risks. An unusual amount of precipitation came down in a short period of time, due to an atmospheric low called 'Bernd' (Lehmkuhl et al., 2022). The hills along the border of Germany and Belgium pushed the airflow up, leading to cooling of the air, generating rainfall (Copernicus, n.d.). In the mountains of western Germany rainfall reached up to 150 mm in a total of 72 hours, which exceeds any average rainfall levels in that area, especially in such a short time period. The Federal State Office for the Environment Rijnland-Palatinate's calculated that the return period of such an event yields values of 1 in around 400 or 500 years, underlining the extremity of the event (Manandhar et al., 2023; Wolf et al., 2024). "The two German federal states of North Rijn-Westphalia (NRW) and Rijnland-Palatinate (RP) were particularly affected, but also the neighbouring countries of Belgium, The Netherlands, and Luxembourg." (Mohr et al., 2023, p. 526). In this paper the focus is aimed at the consequences in The Netherlands.

The effects of the floods within the Dutch borders originate from outside of the borders. At first, on the 13th of July, only a localized overflow of the small watercourses in Western Germany took place. "However, the western part of Rijnland-Palatinate and the southern half of North Rijn-Westphalia were extensively affected on the evening of 14 July..." (Manandhar et al., 2023, p. 11). Since the precipitation persisted until the 15th of July, even the bigger rivers in the area were affected, "including the Ahr, Emscher, Erft, Kyll, Lippe, and Prum" (Manandhar et al., 2023, p. 11). After, the banks of four rivers broke, the "...Wupper, Sieg, Ruhr, and Rur" (p. 11).

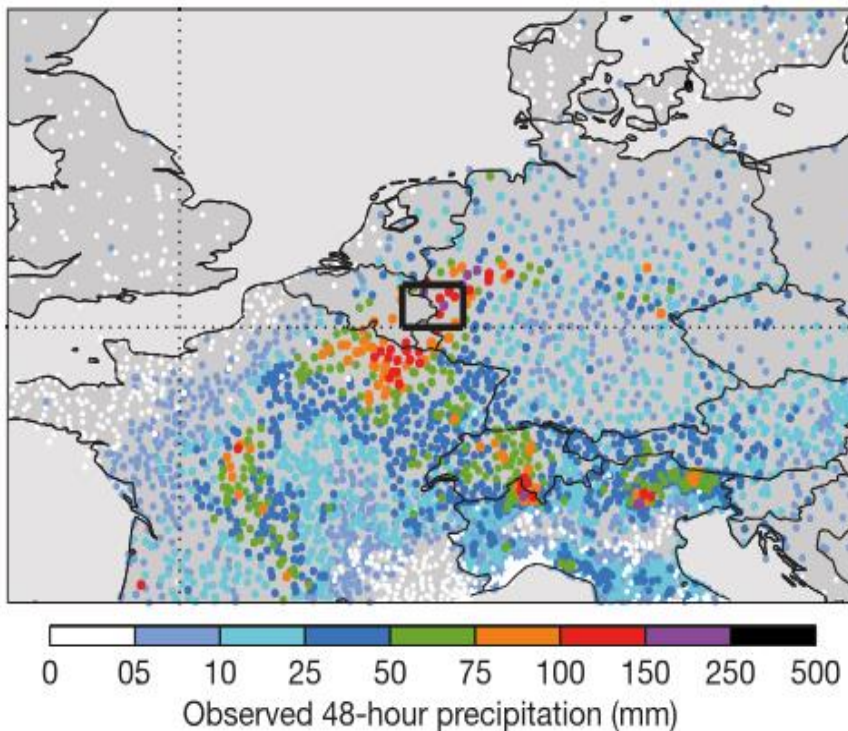


Figure 1: Observed rainfall. The chart shows observations of 48-hour precipitation from July 13th 6 UTC to July 15th 6 UTC. Source: ECMWF (2021).

In Belgium and the north of France a similar process took place, as visible in figure 1. Not only in the mountains near Germany, but also in Wallonia, the southern state of Belgium, a lot of precipitation fell. The effect of this is visible in figure 2, where the flooding of the Maas- and the Rijn River, together with their tributaries, are shown.

Maximum threshold exceeded from 11 to 31 July 2021

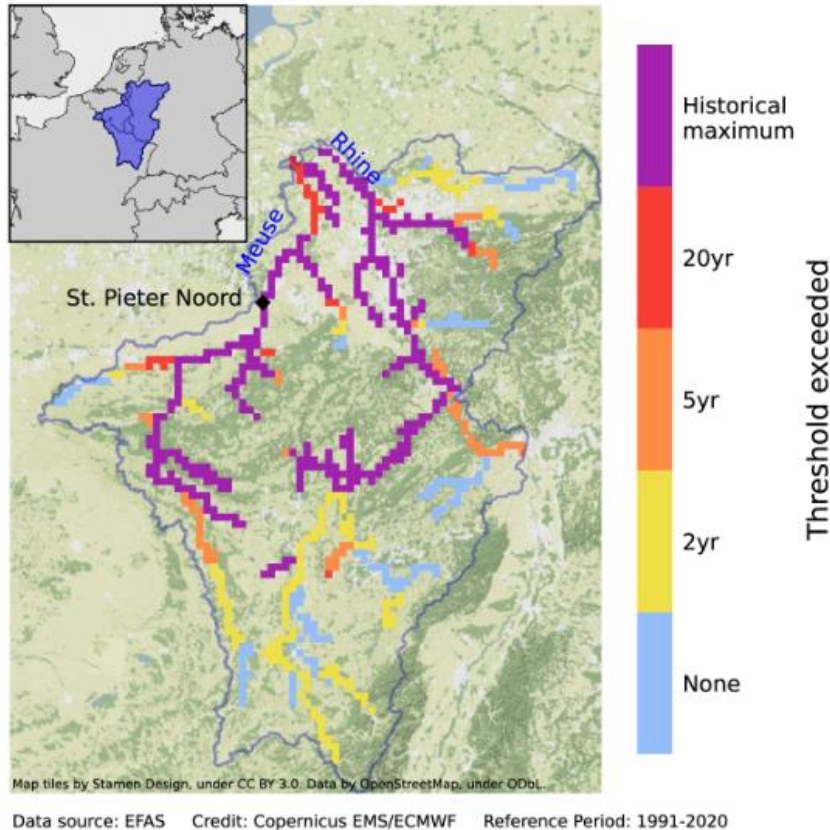


Figure 2: A map of the levels of river discharge of the Maas- and the Rijn River. The colours indicate whether the discharge exceeds the two-, five- or twenty-year flood return period thresholds. The colour purple indicates whether this event was the maximum simulated river discharge since 1991. Source: Copernicus (2021).

As a consequence, an excessive amount of water entered The Netherlands, coming from Germany, Belgium, and Luxembourg. From the German side the water from the Eifel went downstream along the Rijn towards the border. From the south, the Netherlands received an enormous flow of water from Belgium. These flows caused problems in The Netherlands. Multiple floodings occurred in the southern part of the country, in the province of Limburg. Several cities were affected, of which Valkenburg the most severely (Deltares, 2022). Figure 3 provides an insight in what other Dutch areas were affected by the floods. These entailed fluvial floodings, meaning that water bodies (rivers) exceed their water capacity because of intense rainfall elsewhere (Deltares, 2022;ICLR, 2021). These floods had severe consequences. In Germany, Belgium, Luxembourg, and The Netherlands, there were hundreds of victims, millions of homes were flooded, and extensive infrastructure damage occurred (Tradowsky et al., 2023;The New York Times, 2021). These floodings did not only cause cross-border damage, but highlighted the persistent vulnerability of The Netherlands to extreme weather events, despite existing policies. Therefore, the scope of this research is Dutch flood risk management (FRM), in the light of the 2021 floods.

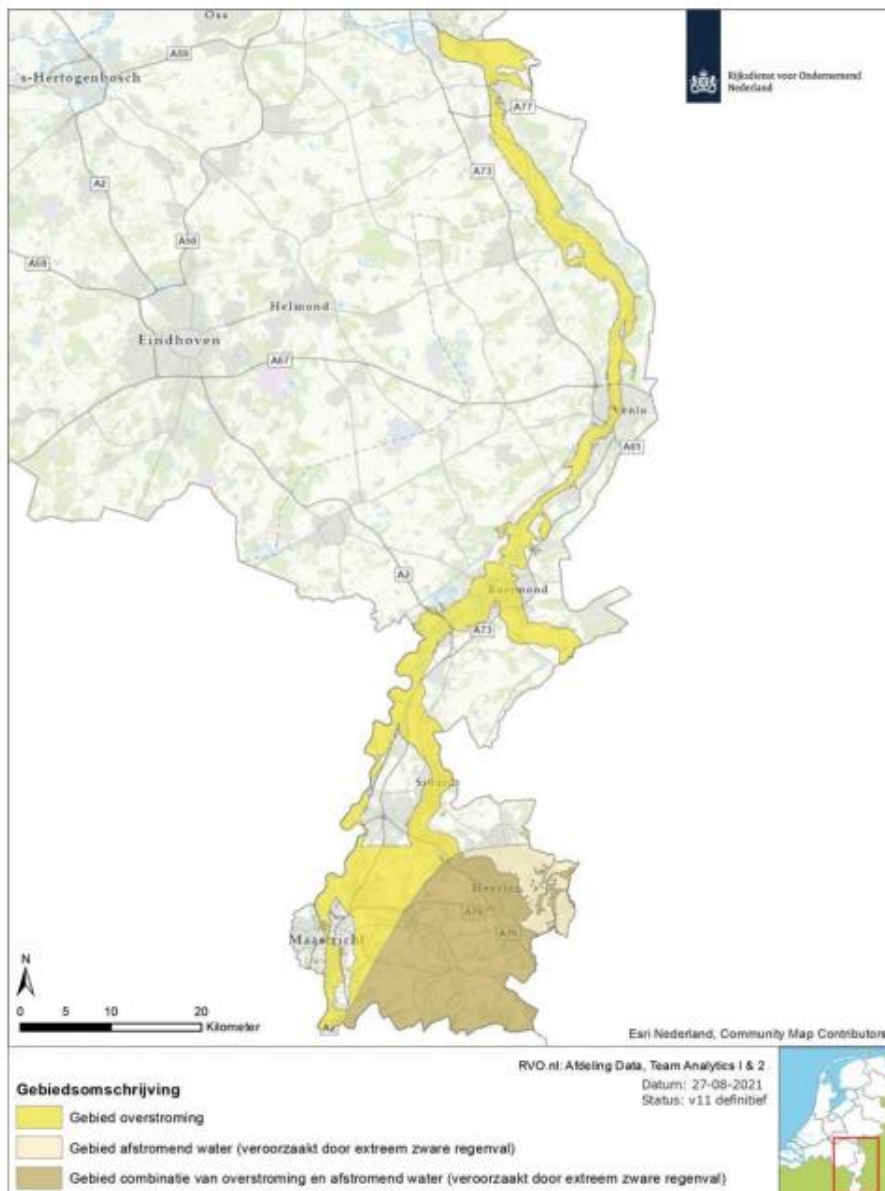


Figure 3: A map of the affected areas in the provinces of Limburg and Noord-Brabant. This map was created by the government to determine which areas will receive funding for the flood recovery. The yellow areas indicate floodings of the river, the beige areas are where the water from heavy rainfall flowed to, and the brown areas are a combination of these two, these areas were the most effected. Source: Rijksoverheid (2021).

Dutch FRM, which entails the process of decision-making and development by the government towards reducing flood risks (Schanze, 2006), seems inadequate in dealing with extreme weather events. The disastrous effects of the floods of July 2021 revealed inadequacies in Dutch FRM, which raises critical questions about the effectiveness of current policies when looking at flood safety in the context of climate change and the increasing occurrence of floods (Najibi and Devineni, 2018). Gleick (2010) even states that if FRM continues down this road, “*unavoidable climate change will alter our planet in increasingly serious ways*” (Gleick, 2010, p. 125), which underscores the urgency of re-evaluating it. This problem raises the question of whether the 2021 flood event has triggered a response in Dutch FRM in order to prevent future disasters, which forms the focus of this study.

Research aim

Given the vulnerabilities exposed by the 2021 floods, this research investigates whether the flood event of July 2021 acted as a *shock event* that triggered policy change. *Shock events* can be described as sudden, relatively uncommon, harmful, or revealing possible future harm, and this harm is known to both policymakers and the public (Birkland, 1998, p. 54). These characteristics create opportunities for learning and adapting to change, often serving as catalysts for policy transformation (Kaufmann et al., 2016). Through performing an analysis of the governance response to the floods, this study aims to identify lessons that can be drawn in order to improve future flood resilience in The Netherlands. Insights into FRM dynamics will inform policymakers about the effectiveness of current strategies and policies, and how they can be improved (Ministerie van Verkeer en Waterstaat, 2010). By evaluating policies in the extreme context of flood events like the July 2021 floods, this research contributes to the broader goal of enhancing Dutch flood resilience. This is particularly urgent in the light of increasing climate risks (Gleick, 2010; Tradowsky et al., 2023).

To perform this research the following main research question is established: '*Did the July 2021 flood event in The Netherlands act as a shock event that triggered policy change in Dutch flood risk management and how?*'. The answer to the research question and the possible lessons learned through this event will be formed through answering the following sub-questions:

1. Can the flood event of July 2021 be considered a *shock event*?
2. What were the main stabilising factors hindering policy change after the floodings of July 2021?
3. What were the main factors that contributed to policy change after the floodings of July 2021?
4. What policy lessons could be drawn from the Dutch flood risk management response to the flood event of July 2021?

The theories and methods that will be used in order to answer these research questions will be discussed in the theoretical framework in chapter 2 and the methodology in chapter 3.

1.3 Scientific relevance

In this section the scientific relevance of this research will be discussed. First, this study contributes to existing knowledge of flood risk management (FRM) through expanding the knowledge about the floodings of July 2021 functioning as a potential *shock event*, and its role in triggering policy change. While studies, such as the one of Pot, De Ridder and Dewulf (2024), explore the lessons that could be learned from the floodings in July 2021 within FRM, and Lemkuhl et al. (2022) who perform a scientific analysis of the floods, limited attention has been given to the potential of this event to be considered a *shock event*, meaning that it would have triggered policy change. An example of a previous analysis is the extensive article of Köhler et al. (2023) that highlights the effect of frequent flood events on adaptive behaviour and resilience, but lacks the link to the concept of a *shock event*. Therefore, this study is among the first to examine the 2021 flood event in the Netherlands through a policy change and *shock event* lens, and adds to the scarce literature on adapting caused by *shock events* on an international level. This is in line with the statement of Birkland (2006) that overall limited research on the causal mechanisms linking extreme weather events to policy change has been done. By focusing on this potential catalyst role, this study adds a novel focus to the existing FRM discourse on this specific event. In addition, this relevance supports the research aim of this study to investigate whether this specific flood acted as a *shock event*.

Moreover, this research gives theoretical and practical insights into the broad academic discussion of governance. By applying the ‘forces of stability and change’ framework of Wiering et al.(2018) in evaluating potential policy shifts, this research contributes to the discussion on the dynamics between institutional resilience and the need for adaptive governance in FRM through a case-analysis. A considerable amount of research has been performed targeting these dynamics, for example the article of Köhler et al. (2023) that was mentioned before. However, although adaptive governance is seen as a key strategy in dealing with climate risks, not much empirical research on how it manifests in practice as response to one specific event has been conducted (Folke et al., 2005). This creates a knowledge gap in the analysis of these dynamics in practice, which this study of the specific governance environment around the 2021 flood event adds to.

In conclusion, studying the flood event of July 2021 within this study contributes to the existing literature on *shock events*, FRM, and adaptive governance. By combining an empirical analysis with a theoretical lens, this study strengthens the understanding of how extreme weather events can serve as learning points in environmental policy. In addition, the study will provide a case specific analysis of FRM policies in the Netherlands, contributing to knowledge on Dutch FRM, which indirectly adds value to international literature. Finally, the generated knowledge of this study will help answer the research questions of this paper.

1.4 Societal relevance

In addition to the scientific relevance, this research holds significant societal relevance since it addresses improving flood resilience in the Netherlands, guarding the population’s safety. This is quite necessary, since climate change contributes to a higher “...*probability of the occurrence of potentially damaging flood events...*” (ITC, 2004, cited in Schanze, Zeman & Marsalek, 2006, p. 2). Another very recent flooding example, in addition to the case of this research, are the floodings caused by storm Pia in December 2023, underlining the urgency. This storm resulted in high sea-levels along the Dutch coast, and the Dutch storm surge barriers needing to close. All six barriers were closed, which is a unique situation. The last time that had occurred was in 2018, while the closing level had been lower. In addition to the high water levels, the storm did a lot of damage to vegetation, vehicles, and the built environment (Rijkswaterstaat, 2023).

Approximately 60% of the Netherlands is being protected against floodings through the implementation of flood defences such as dikes, dunes, and dams (Ministerie van infrastructuur en waterstaat, 2022). However, approximately 9 million people live in the other 40% of the country, causing higher flood risks. This is becoming a bigger problem since the population keeps growing, the economic value of this area keeps rising, and approximately 70% of the gross national product is earned here. In addition, floods also have a major economic impact. Deltares (2023) estimated the total damage costs of the July 2021 flood event for individuals, businesses, and governments at 433 million euros. As concluded in a study of the Vrije Universiteit in Amsterdam, it is of great importance to improve the Dutch FRM, in order to reduce these physical and economical impacts, to which this research aims to contribute (Vrije Universiteit, 2023).

Finally, since all the aims mentioned in the previous paragraphs offer support for evidence-based policymaking, this research nurtures a broader societal benefit. A more resilient and sustainable approach to water- and flood risk management protects the population against direct threats, but also improves the Dutch long-term adaptive capacity to climate change. This aligns with the international urgency to obtain a more transformative form of climate change

governance to address the challenges climate change brings (Schanze, Zeman & Marsalek, 2006; Plate, 2002).

1.5 Outline of thesis

This thesis' structure is organized as follows. First, chapter 2 introduces the key-concepts. Secondly, it discusses the theoretical framework, existing of three approaches. At the end of chapter 2 the conceptualisation of the concepts is presented. Chapter 3 dives into the methodology of this thesis, which is a single case study of the governance response to the floods in 2021 in the Netherlands, with a focus on the province of Limburg. Chapter 4 provides an overview of the main findings of the analysis and chapter 5 discusses those findings. Finally, in chapter 6 the research questions will be answered, and chapter 7 concludes this thesis with a reflection.

2. Theoretical framework

This chapter will provide an overview of the concepts and theories relevant to this research. The chapter begins with an overview of literature considering climate change, climate change adaptation, floods, flood risks, flood risk management (FRM), and *shock events*. In the second section the policy approaches will be discussed, together with an operationalization of the concepts and an own conceptual model.

2.1 Climate change and climate change adaptation

As mentioned in the introduction, climate change is a worldwide phenomenon caused by the process of global warming (Gleick, 2010; Ziegler and Muchira, 2023). As discussed, effects of climate change include hazards in the fields of heat problems, sea level rise, water temperature rise, heavy rainfall, and floodings, amongst many other consequences (Brimblecombe et al., 2020). Therefore, it can be stated that the growing problem of climate change poses many risks for the human population. This section of chapter 2 builds upon those climate change risks by firstly elaborating on the strategy of climate change adaptation to counteract climate change. Secondly, this section narrows down to the specific climate change effects of floods, and flood risks. Lastly the concept of *shock events* will be further introduced.

In addressing climate change risks there is a distinction between climate change mitigation and climate change adaptation. Climate change mitigation entails acting in order to prevent climate change and its effects from happening (Wredford, Moran & Adger, 2010). A practical example of climate change mitigation is the increase of sustainable biofuel production in order to reduce the use of unsustainable forms of fuel. Climate change mitigation tries to decrease the speed at which climate change is happening by addressing unsustainable patterns and problems at the core, by trying to change behaviour.

On the other side, lays climate change adaptation. In general, "*Adaptation to climate change is typically characterized as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts, in order to alleviate adverse impacts of change or take advantage of new opportunities*" (Wredford, Moran & Adger, 2010, p. 59). This citation states that climate change adaptation entails minimizing the

impacts of climate change effects and taking advantages of opportunities climate change effects may bring (Wredford, Moran & Adger, 2010). Therefore, climate change adaptation can be summarized as the adjusting to climate change effects. This includes measures such as the establishment of the *Ruimte voor de Rivier* programme in 2000 and the Maaswerken programme in 2005. The *Ruimte voor de Rivier* programme provides more room for rivers to discharge greater volumes of water in a nature based, for example through relocating dikes or lowering of the groynes (Ministerie van Verkeer en Waterstaat, 2010). The latter, the river widening programme of the Maaswerken, broadens the river Maas through gravel extraction (Rijkswaterstaat, n.d.-a). Since 2013, the development of such new climate adaptation solutions and strategies is officially supported by a formal EU strategy on adaptation to climate change, underlining its importance (Van Loon-Steensma & Goldsworthy, 2022). Despite the attention for, and major investments in climate adaptation in the field of water, including flood protection, flood forecasting, and flood preparation, flooding events in central Europe still cause damage and other casualties (Vitale, 2023). This stresses the still withstanding vulnerability and exposure to floods.

Floods and flood risk

A flood can be defined as “...a temporary covering of land by water outside its normal confines.” (FLOODsite-Consortium, 2005; Munich Re, 1997, cited in Schanze, Zeman & Marsalek, 2006). This can be caused by different triggers, such as intense rainfall, an above average level of snowmelt, or high-water levels caused by storms or tsunamis. These different causes create much different variations of floods; “winter rainfall floods, summer convectional storm induced floods, snow-melt floods, sea surge and tidal floods, tsunamis, rising ground water floods, urban sewer floods, dam break or reservoir control floods.” (Penning-Rowsel and Peerbolte, 1994, cited in Schanze, Zeman & Marsalek, 2006). Overall, they can be categorized in three most common types of floods according to the World Health Organization (2019). These categories contain flash floods, which are caused by fast and excessive amounts of rainfall that cannot flow away, river floods, caused by consistent rain or snow melt, and coastal floods, often caused by storms. As previously mentioned, this paper focusses on river floods, also called fluvial floodings. This entails a “river or riverine flooding, when levels in a river, creek or stream rise, allowing water to flow onto surrounding land” (ICLR, 2021, p. 3). This overflowing can be caused by an individual phenomenon, like extreme rainfall, or by multiple phenomena happening all at once. Fluvial floods appear to happen more frequently (Wilby et al., 2007), which can be explained by the increasingly frequent heavy rainfall caused by climate change (Arnell & Gosling, 2014). Another kind of flooding relating to heavy rainfall, which will not be further discussed in this thesis, are pluvial floodings. These are floodings that do not include a waterbody overflowing (ICLR, 2021, P. 16). In this case, the rainfall exceeds the infiltration capacity of the soil, or the soil is already saturated when the rainfall occurs, and the water cannot be absorbed, and it continues to flow over land (Arnell & Gosling, 2014; Kron, 2002). In this context, saturation entails the extent to which the ground can absorb water. Therefore, the same effect could occur when the ground is frozen during a heavy rainfall event. In addition, because of a growing surface of impermeable materials in cities, like roads and roofs, water cannot be easily absorbed into the ground (Qin, 2020).

This phenomenon causes water to flow over land towards waterbodies such as rivers or lakes. While the excess of water moves towards larger waterbodies, and when it reaches the river, it can cause sediment to come loose (Kron, 2002), enabling floodings to become extremely dangerous. Examples of sediment are soil, branches, trees, waste, and so forth. When such a

flood caused by heavy rainfall occurs independently on a local level it can be called a flash flood (Kron, 2002). In the case of flash floods the ground does not need to be fully saturated to cause a flood, but the infiltration speed of the soil cannot keep up with the rate at which the precipitation comes down. Another physical factor that could create a flash food is a lack of elevation in the area of the rainfall, preventing the water to runoff.

When a flood, such as the ones above, happens, this is called a *flood hazard*. The risk of a *flood hazard* is called a *flood risk* can be interpreted in different ways. In general it consists of the possibility of a flood to occur, the *flood hazard*, and its consequences (Kron, 2002). Because “Where there are no people or values that can be affected by natural phenomenon, there is no risk.” (Kron, 2002, p. 85).. Kron (2002, p. 86) therefore provides three components to define a risk:

1. “The hazard: the threatening natural event including its probability of occurrence.”
2. “The exposure: the values/humans that are present at the location involved.”
3. “The vulnerability: the lack of resistance to damaging/destructive forces.”

The concept of a *flood hazard* is similarly defined by Schanze, Zeman & Marsalek (2006), to which they add that the damage done by flood hazards depends on the vulnerability, which is also in line with the components of Kron (2002). Moreover, Schanze, Zeman & Marsalek (2006) distinguish different forms of vulnerability. Firstly, “Social and cultural vulnerability refers to loss of life, health impacts (injuries), loss of vitality, stress, social impacts, loss of personal articles, and loss of cultural heritage. Economic vulnerability alludes to direct and indirect financial losses by damage to property assets, basic material and goods, reduced productivity, and relief efforts. Ecological vulnerability comprises anthropogenic pollution of waters, soils, and ecological systems with their biota” (Messner and Meyer, cited in Schanze, Zeman & Marsalek, 2006, p. 2). Combining these different definitions, the concept *flood risk* can be defined as the risk of negative consequences following a flood hazards, which depends on the exposure and vulnerability of the elements that are at risk.

Flood risk management

A key component within climate adaptation strategies that try tackling flood risks is flood risk management (FRM). The concept is briefly touched upon in the introduction of this paper, and this section builds on that foundation by further elaborating to enhance a better understanding of the concept. To start, an explanation is given, after which the focus will shift to contemporary dynamics within FRM.

FRM includes all the activities that control the decisions and actions aimed at reducing flood risks and the negative consequences of floods (Schanze, Zeman & Marsalek, 2006). According to Ansell (2022) it involves the coordination and management of policies, resources, stakeholders, and processes in order to achieve common goals. This coordination stems from flood risk governance, which Ansell (2022) defines as the processes and structures by which organisations, societies, or communities make decisions and exercise authority. Schanze, Zeman, and Marsalek identify two key interpretations of FRM. The first approach separates the flood risk analysis from the actual FRM, where the risk is analysed first, followed by implementing management strategies (Marsalek 1999; Hooijer et al. 2004; Oumeraci 2004, cited in Schanze, Zeman & Marsalek, 2006, p. 4). On the other hand, “The second understanding defines management as decisions and actions undertaken to analyse, assess and (to try to) reduce flood risks. In this case [FRM] covers the risk analysis, risk assessment and risk

reduction” (Plate, 1998; Sayers et al., 2002; Hall et al., 2003, cited in Schanze, Zeman & Marsalek, 2006). While both of the approaches are valid, this research adopts the second approach, since it aligns with the contemporary approaches to addressing risks in an integrated and dynamic manner (Vitale, 2023). Within this process, multiple actors play a role, and the shape of this process is very context dependent, causing a wide range of different definitions and “*political, administrative, planning, and cultural systems*” (Schanze, Zeman & Marsalek, 2006, p. 5).

Furthermore, a change in thinking has been triggered within FRM, which started to move the field from the traditional approach, called the *standard-based approach* (SBA), to the more modern *risk-based approach* (RBA). The SBA is mainly focused around keeping floods away through hard measures by analysing the load that these hard measures are expected to withstand (Vitale, 2023). While this approach is effective on short terms, it lacks flexibility and adaptability to potentially changing conditions in the future. On the contrary, RBA is focused on tackling actual present risks in combination with future risks. This approach includes a large spectrum of measures and strategies, including having multiple actors from different dimensions. An example is the multi layer safety approach from the water plan in 2009 (Ministerie van Infrastructuur en Waterstaat, 2009). This approach “[...] aims to integrate flood prevention with resilient spatial planning and disaster management to decrease both probability and consequences of flooding within one approach” (Bosoni, Tempels & Hartmann, 2021). In short, the RBA can therefore be summarized as follows, “...[it] accounts that there is a full set of causes and plausible ways in which food risk patterns may change (perhaps significantly) in the future and thus seeks to embed adaptive capacity and resilience within policy responses.” (Sayers, 2017, cited in Vitale, 2023).

Shock events

Within this subsection a deepening of the definition of *shock events* is given by using the articles of Birkland (1998) and Kaufman et al. (2016). Birkland speaks of *focusing events* in his article, which can be defined as sudden, uncommon events of which the harm, or the possible harm, triggers policy change (Birkland, 1998). Possible harm refers to its ability to reveal the possibility of harm (Birkland, 1998, cited in Kaufman et al., 2016). For this reason, Kaufman et al. (2016) state that they test the capacity to resist and bounce back, which provides opportunities for adapting and learning. This way, the events are able to facilitate a shift towards other forms of resilience (Kaufman et al., 2016). Although Birkland (1998) uses the term *focusing event*, Kaufman et al. (2016, p. 2) “[...] understand a shock event as a focusing event [...] that has created considerable stress waves in a society”. The focus of Birkland (1998) on possible harm implies that the event does not necessarily need to cause harm, and that potential harm is sufficient enough to cause institutional change. However, in recent literature on flood risk management (FRM) the term *shock event* is used to emphasize that the event already had a certain effect (Wiering et al., 2018; Kaufman et al., 2016). This created shock amongst the public and authorities “[...] is the starting point to assess what kind of effect the event had, and to what extent it is a long lasting effect.” (Kaufman et al., 2016, p. 2). Therefore, in this thesis the term *shock event* is used to better reflect the disruptive character of the floods and to align with the terminology in recent literature. To define a *shock event*, the same characteristics as of Birkland’s (1998) *focusing events* are used: the suddenness or unpredictability of an event, its (possible) harm, and the institutional responses.

Within the suddenness of an event indicators entail the warning signs of the event, and the time between this detection and the actual occurrence. The characteristic of (possible) harm entail the number of victims, the financial costs of rebuilding, and the geographical scope for example (Glaus, Gavilano & Ingold, 2024; Birkland, 1998). However, according to the paradigm shift theory of Glaus, Gavilano, and Ingold (2024), events can only become *shock events* when they activate policy change. For this reason, this can be considered the main criteria for a *shock event*. Although, they state that the other characteristics do contribute to the likelihood of an event becoming a *shock event*, because “...chances for change are higher if a shock is very close, be it in terms of geographical distance, or between the nature of the shock and the needs in the subsystem.” (Glaus, Gavilano & Ingold, 2024, p. 162). How *shock event* are able to trigger policy changes works as follows: the events “often lead to changes in the dominant topic of discussion and changes in attitudes towards [existing] policy” (Birkland, 1998, p. 64). This could then highlight inefficiencies, deficiencies, or failures of the existing policy design (Glaus, Gavilano & Ingold, 2024).

To provide a better understanding of *shock events*, an example from Dutch history will be given. In 1953 the most notorious flood disaster happened. It is even considered the biggest Dutch Natural disaster of the twentieth century (Rijkswaterstaat, n.d.-b). A severe storm combined with spring tide caused peak water levels above 4.55m NAP in Vlissingen, causing the water to breach over 150 dikes along the coastline. It is stated by Rijkswaterstaat (n.d.-b) that the calamity occurred due to poorly maintained, weakened dikes, exacerbated by post-war recovery priorities that limited investments in water safety, in combination with the suddenness of the event. In response, Rijkswaterstaat led the repair of dikes, and the Delta Act was established. This includes safety standards for water barriers in the Netherlands, and building flood defences. The Dutch now own more than 3.700 km of the latter, protecting them from such disastrous floods. The suddenness of the occurrence, harm of the flood, and the implementation of new policies and programmes after the occurrence of the flood disaster characterise this flood event a *shock event*.

2.2 Stability and change in policy arrangements

This section will introduce multiple frameworks relevant to understanding policy change dynamics in the context of *shock events*. Before presenting the theoretical frameworks adopted in this study, a brief discussion of alternative theories is provided to explain why these were not selected. After this reflection, the Policy Arrangements Approach (PAA) by Tatenhove, Arts, and Leroy (2000) and the Forces of Stability and Change Framework (FSCF) by Wiering et al. (2018) are presented in 2.2.1.

Frameworks of forces of stability and change

Several frameworks are developed to analyse changes in the policy environment, which have proven helpful in analysing changes in such a complex legal environment. The Multiple Streams Framework (MSF) by Kingdon (1984) states that policy is most likely to change when a policy entrepreneur takes advantage of a window of opportunity, which is created by coupling the individual streams of problem, policy, and politics (Asante, 2023). In this procedure the problem stream represents the problem that needs addressing, the policy stream represents the possible solution, and the politics stream entails the political support. In this framework policy entrepreneurs are individuals/organizations that engage in policy activity with a specific goal in mind. The policy window is defined as critical moment that can be used to push the

entrepreneurs' ideas. An example of such a window is a *shock event* (Wiering et al., 2018). However, since this framework is mostly suited for gradual changes in a rather stable policy environment, and lacks depth about factors in favour of- or against change, it could be seen as less suitable in the context of this research.

A second framework on policy change is the advocacy coalitions framework. At the core, the assumption lies that coalitions of actors can be found in each policy sub-system competing with ideas of other coalitions (Wiering et al., 2018). These coalitions are called advocacy coalitions, of which the members share beliefs and resources, according to Sabatier and Weible (2007, cited in Wiering et al., 2018). The authors describe the interactions between the coalitions as rigid and based on deep core beliefs. A *shock event* could be an explanatory factor of policy change in this context, but since this approach requires more than ten years of analysis due to the slow processes, it does not fit this case study of one flood event.

A model that fits better within the context of this research is the Policy Arrangement Approach by Tatenhove, Arts, and Leroy (2002), which addresses the tension between stability and change in policy processes. The framework was established “...to analytically link changes in day-to-day policy practices to broader structural changes in contemporary society” (Liefferink, 2006, p. 45). On the other hand, it allows an analysis of changes in arrangements in response to specific events through four interwoven dimensions within. Policy arrangements can be defined as “temporary stabilisations in ongoing processes of institutionalisation” (Liefferink, 2006, p. 47). However, the structure of such an arrangement could differ, and those differences can be analysed among different dimensions. The PAA consists of four dimensions; the rules of the game, resources/power, actors, and discourses, which are visible in the tetrahedron in figure 4.

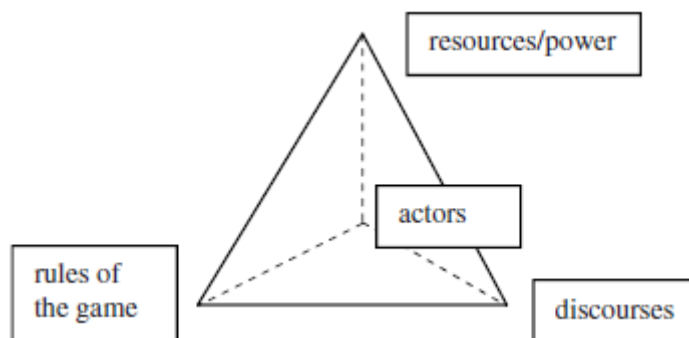


Figure 4: The tetrahedron of Liefferink (2006) of a policy arrangement.

Firstly, the rules of the game refer to the informal and formal terms, routines, or rules that are in play. They could address processes such as interaction, decision-making or other procedures. Secondly, the dimension of resources and power refers to the capacity of the actors and their coalitions, which is the third dimension of the tetrahedron. This capacity exists of the attained resources, which could exist of materials, knowledge, money, and so forth. The mobilisation and distribution of these resources can in turn influence the power distribution within an arrangement. Lastly, the discourses dimension refers to current policy discourses, which entail views and narratives of the involved actors. This could exist of values, principles, norms, and definitions for example. The discourses dimension is also the part of the tetrahedron where new ideas may enter. The tetrahedron shape symbolises this interconnectedness between the dimensions, which means that if changes or new ideas occur in one dimension, this will most likely cause changes in other dimensions too. Another source of change is the context in which the tetrahedron is located. The framework is not operating in a vacuum or isolated environment,

but it is part of society and the social world. Shifts or events in this broader society could, for instance, influence power relations between actors, or limit the availability of resources (Lieverink, 2006). When using this framework in analysing policy arrangements each of the four dimensions of the tetrahedron can be taken as a starting point of the analysis. Through choosing a dimensional focus, different aspects of the whole arrangement are highlighted, making the framework usable for researching policy arrangements in different contexts (Lieverink, 2006).

The second framework that suits this research is the Forces of Stability and Change framework (FSCF) of Wiering et al. (2018), which is linked to the Policy Arrangement Approach (PAA) above. The PAA “... can serve as an operational framework to ‘map’ and characterise stability and change in different dimensions of flood risk management.” (Wierink, Liefferink & Crabbé, 2018, p. 231). In simpler words, the PAA conceptualizes a policy arrangement as a temporary stabilization of an organization and its contents, which can then be analysed through the four interrelated dimensions of the PAA framework. The table of the FSCF, which is visible in figure 5, systematically aligns the forces of stability and forces of change in the different dimensions of the PAA framework. Stability can be understood as existing arrangements that withstand change from happening due to institutional stagnation, path dependencies, and coalitions. Change, on the other hand, is perceived as disruptions within policy caused by events, new coalitions, or shifts in the discourse challenging current policy. The four different dimensions originate from the PAA discussed above, which include actors, resources, rules, and discourses.

Forces of stability	Dimensions of policy arrangements	Forces of change
– <i>Coordination effects</i> : governance is sedimented in specific divisions of accepted responsibilities	Policy actors and coalitions	– Entrepreneurs highlighting perception of sub-optimality of governance and approach – Strong pressure by specific interests (actor coalitions)
– <i>Fixed costs and increasing returns</i> through large investments in flood infrastructure (sunk costs)	Power and resources	– Doubts on increasing costs of flood infrastructure/ maintenance or sudden financial cutbacks, opening alternative options – New expertise (learning)
– <i>Learning effects</i> : evolution of strong expert body of knowledge and strong epistemic community	Rules of the game	– Decreasing legitimacy of rules – New rules (e.g. European Floods Directive)
– Law has an important stabilising effect in the formalisation of rules and procedures	Policy discourses	– Diminishing trust in existing institutions and their efficiency – New ideas, new problem definitions and policy concepts leading to counter-narratives
– <i>Adaptive expectations</i> : public trust in existing institutions and their efficiency		

Figure 5: The forces of stability and change framework of Wierink, Liefferink & Crabbé (2018)

Within this framework, the four dimensions of the policy arrangements mechanism interact with each other, creating forces of stability and change, which are visible on the left- and right side of the table. Firstly, on the stability side, coordination effects are stated. This entails the institutionalisation of flood policy in governance structures by clearly assigning specific responsibilities to different sectors, governance levels, and actors. This distribution makes it harder to introduce alternatives later on. Secondly, fixed costs tied to investments in flood infrastructure, such as dikes and barriers, reinforce stability. These sunk costs discourage radical changes because significant financial investments have already been made. Thirdly, learning effects create another stabilising force: as technical knowledge and expertise grow around existing infrastructures and policies, the policy community becomes more entrenched,

making alternative approaches less likely. The stronger the focus of knowledge, the more difficult it is to discover, or bring up, alternatives. Fourth, law strongly regulates through formalising rules and procedures, which ensures that the rules of the game resist change. Lastly, strong historical narratives and adaptive expectations about flood management form a stabilising force within the policy discourse dimension. Public trust in existing strategies and institutions strengthens the preference for maintaining familiar governance approaches rather than seeking innovation.

Although, Wiering et al. (2018) state that most changes in policy dynamics are strongly influenced by the agency – meaning the strategic actions and choices of actors - amongst researchers and actors, the framework also identifies distinct forces of change. On the side of change in the framework those different factors of change are stated. In the actor dimension, change is driven by actors and coalitions that highlight the suboptimality of existing arrangements or promote specific interests that challenge these current arrangements. These actors seek to expose inefficiencies, outdated approaches, or new vulnerabilities that the current governance system fails to address. Secondly, within the dimension of power and resources, change occurs when doubts and new expertise occur. Those doubts often concern increasing flood risk management costs or setbacks, which opens up new options. This can alter the distribution of resources and influence among actors, for instance by strengthening those advocating for innovative or more cost-effective flood risk solutions. Third, the rules of the game dimension changes when existing rules lose their legitimacy, either through being perceived as ineffective or new ones being established. An example is the European Floods Directive, a legislation that tries to minimize flood risk on an international scale, which would require adjustments to current national flood risk governance. Last, in the policy discourse dimension, change can originate in diminishing trust in the historical and current narratives that have justified contemporary flood management strategies. When such dominant ideas lose credibility new ways of problem framing can emerge, acting as counter-narratives. These can introduce new values and/or goals, challenging the previously dominant discourse. This could potentially reshape flood risk governance. Overall, this structured way of presenting these forces enables analysing and characterizing the dynamics in flood risk management in a structured way, linking theoretical insights to practical policy evaluation. It could be considered an “*integrated and comprehensive analytical framework*” (Wiering et al., 2018, p. 237) since it integrates key policy change concepts like path dependency,

2.3 Operationalisation

The case of the 2021 flood event in The Netherlands offers a unique opportunity to study whether and how this event functions as a shock capable of triggering change in FRM. In order to perform this analysis the different variables are operationalised in this section. Table 1 presents an overview of all the concepts mentioned in the sub research questions, their dimensions and the indicators for those dimensions. This table is established through using the literature previously discussed in this chapter. The dimensions and indicators of *shock events* are based on Birklands’s (1998) concept of *focusing events*; sudden, rare, harmful, and known to the public and policymakers. The factors of stability and change, its four dimensions, and the indicators originate directly from the FSCF by Wiering et al.(2018).

Concepts	Dimensions	Indicators	
Shock event	Suddenness / unpredictability	Presence/absence of warning signs	
		Time between detection and impact	
		Perceived unexpectedness by public or authorities	
	(Possible) harm / magnitude	Number of casualties	
		Extent of financial damage	
		Geographical scope	
		Severity of disruptions to infrastructure or services	
	Institutional responses	Initiation of policy discussions	
		Adoption of new policies or procedures	
Public or political framing of the event as exceptional			
Factors of change	Actors and coalitions	Entrepreneurs highlighting perception of sub-optimality of governance and approach	
		Strong pressure by specific interests (actor coalitions)	
	Resources and power	Doubts on increasing costs of flood infrastructure/ maintenance or sudden financial cutbacks, opening alternative options	
		New expertise (learning)	
	Rules of the game	Decreasing legitimacy of rules	
		New rules (e.g. European Floods Directive)	
	Policy discourses	Diminishing trust in existing institutions and their efficiency	
		New ideas, new problem definitions and policy concepts leading to counternarratives	
	Factors of stability	Actors and coalitions	Coordination effects: governance is sedimented in specific divisions of accepted responsibilities
			Resources and power
		Resources and power	Fixed costs and increasing returns through large investments in flood infrastructure (sunk costs)
			Learning effects: evolution of strong expert body of knowledge and strong epistemic community
Rules of the game		Law has an important stabilising effect in the formalisation of rules and procedures	
Policy discourses		Strong historical narratives	
		Adaptive expectations: public trust in existing institutions and their efficiency	

Table 1: operationalisation table. Source: own.

The left column of the table provides an overview of the concepts from the sub-questions. In the second column from the left, the dimensions of those concepts are listed. Lastly, in the rightmost column, the indicators of the dimensions are presented.

Conceptual model

The conceptual model of this research is based on the Forces of stability and change framework by Wiering et al. (2018) and the articles of Birkland (1998) and Glaus, Gavilano, and Ingold (2024) about *shock events*.

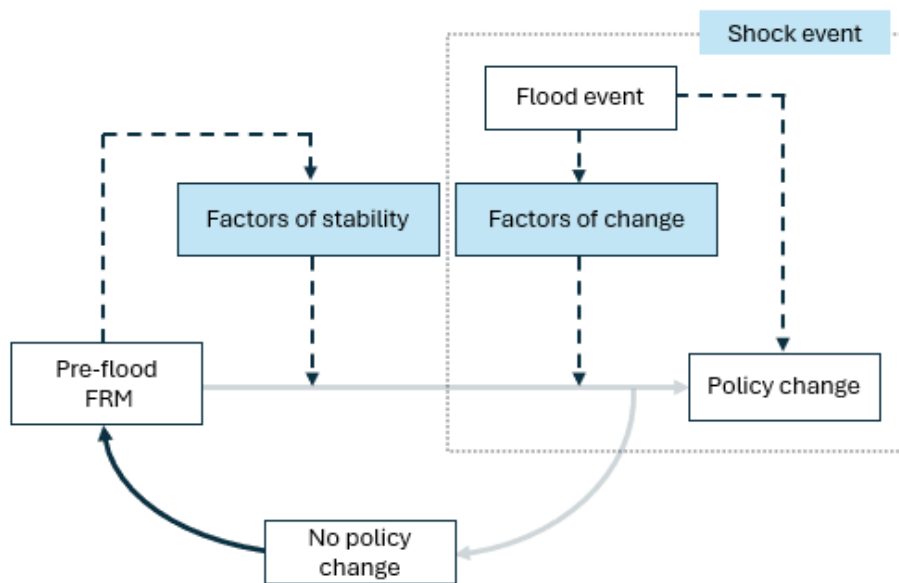


Figure 6: Conceptual model. source: own.

In the conceptual model above the influence of a flood event, factors of stability, and factors of change on pre-flood FRM is visualised. The relationships between the concepts flow in the direction of the arrows, and the boxes of the main concepts of this study are blue. The white boxes represent dimensions and other relevant constructs. The dark solid line represents a direct relationship, while the solid light grey lines represent possible consequences in the process over time. Dashed lines represent the influence of concepts on other concepts and processes, and the light grey dotted square includes the concept *shock event*. The box of factors of change is included in the *shock event* concept, since the pressure of these factors can be related to the consequences of the potential *shock event* according to Birkland (1998). The model starts in the pre-event FRM situation. When a flood event occurs, different factors exercise pressure on the pre-flood FRM. This could lead to policy changes, or the FRM withholds. In the first case, the event entails characteristics of a *shock event*. As previously discussed, the other dimensions of *shock events* such as the suddenness and (potential) harm can be used alongside this framework to potentially discover *shock events*.

3. Methodology

In this third chapter the methodology guiding the research is outlined through the use of the research onion model for developing a research design of Saunders et al. (2016) is used (see figure 7). By using this model, the methodology chapter follows the layers of the onion from the outside to the inside, providing a clear structure. In addition, the social research methods book by Bryman (2016) is used. The first section, 3.1, explains the research philosophy of this research, followed by the approaches to theory development in section 3.2. Thirdly, the methodological choices are elaborated upon in section 3.3. In section 3.4 the research strategy is described, and the time frame in 3.5. The last ring of the research onion about the techniques and procedures within the data collection and -analysis is discussed in section 3.6. After this, on top of the layers of the onion, the validity and reliability of this research is explained in section 3.7, and the concept of ethics will be discussed in 3.8.

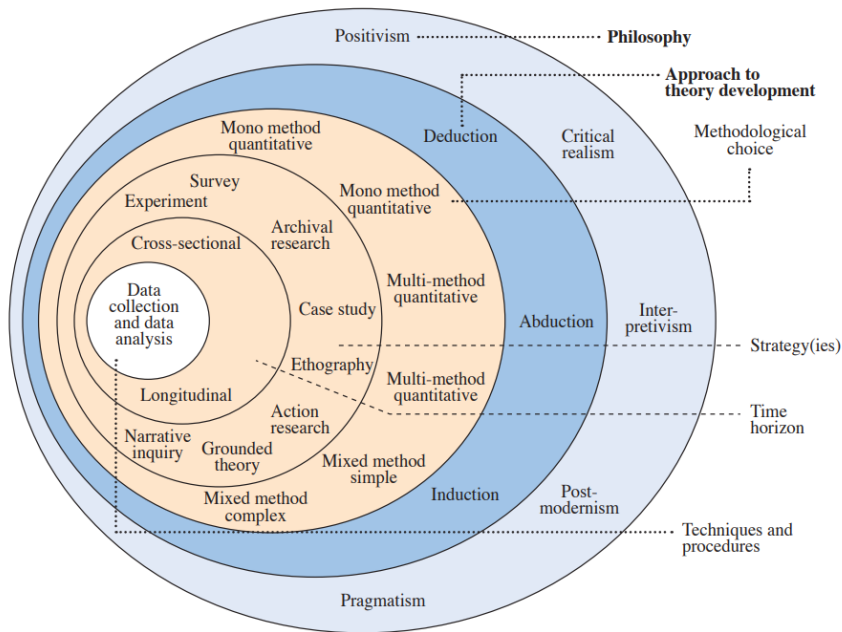


Figure 7: The research onion of Saunders et al. (2016). Source: Melnikovas (2018).

3.1 Research Philosophy

The following section will discuss the epistemological- and ontological considerations of this research, originating from the first layer of the onion (Saunders et al., 2016). This is the research philosophy, referring to beliefs and assumptions on knowledge and ways of knowledge development, which strongly influence the research process. The first kind addresses the nature of reality, and is called ontological assumptions. This concerns questions like whether the social world is something beyond our influence, or if it is very much a product of social interaction (Bryman, 2016). Secondly, epistemological assumptions address the human knowledge and its validity and legitimacy. Shortly, this entails the question of what is regarded as acceptable valid knowledge (Bryman, 2016).

Saunders et al. (2016) distinguish five philosophies within social research; positivism, (critical) realism, interpretivism, postmodernism, and pragmatism. In addition, Bryman (2016) also distinguishes objectivism and constructionism as ontological philosophies. Firstly, positivism is an epistemological position that advocates for the usage of methods in natural science research in social science research (Bryman, 2016). Realism is another philosophical position, which share two features with positivism. This includes the fact that natural research methods can be applied in social research, and that there is a reality separate from our perception of it. Realism has two sides; empirical realism, which states that reality can be fully understood, and critical realism, which states that reality exists, but we can only see it through our own perceptions (Bryman, 2016). Critical realism differs from positivism and empirical realism because it does not imply that our conceptualization of reality actually reflects the reality. Interpretivism, on the other hand, is a term contrasting positivism. It states that the subject matter of social sciences is quite different from that of the natural sciences (Bryman, 2016). It advocates for social scientists to grasp the subjective meaning of social actions, which leaves room for interpretation. Postmodernism is an ontological position that is suspicious of implying that reaching a definite version of reality is possible, and sees knowledge as something indeterminate (Bryman, 2016). Fourth, pragmatism only considers concepts relevant when they play a role in generating action (Saunders et al., 2016). Therefore, it also sees concepts,

theories, hypothesis, and results as roles that they (could) play. Lastly, ontological philosophies also include objectivism, which implies that social phenomena are external facts beyond our reach to influence, and constructionism, which is an alternative of objectivism, stating that social phenomena are continually being formed and influenced by social actors (Bryman, 2016). The difference between these two is that objectivism sees the social phenomena as something static and robust, while constructionism sees it as something that is continuously revising.

Now that all seven philosophies are shortly described and the differences are made clear, their role in this research will be explained. As previously mentioned, the aim of this research is to discover potential policy changes and understanding the dynamics of this process. This implies that there is a separate reality which can be observed, which fits within the realism position. This reality can be observed by the researcher, but since this is biased by an own perception, the actual reality is not directly accessible through own observations. This calls for research to provide an explanation of what is observed. This fits the philosophy of critical realism, since the aim is to “*explain what we see and experience, in terms of the underlying structures of reality that shape observable events.*” (Saunders et al., 2016). In addition, this research is in line with the ontological assumption of the constructionism philosophy, because the reality of the floodings in July 2021 and its potential influence on policies is formed by different aspects, including the social actors within this process.

3.2 Approaches to theory development

Within social research there are three main ways to develop theory; the deductive approach, the inductive approach, and the abductive approach. The deductive approach entails the researcher drawing on what is known in order to form a hypothesis that will then be tested (Bryman, 2016). In order to test this hypothesis it must be translated into operational terms to know how data should be collected. Within this approach theory is the basis where a hypothesis is being deducted from. After the findings have confirmed or dismissed a hypothesis, a revision of theory is performed, and the findings are fed back into theory. An inductive relationship between research and theory is, in general, mostly associated with qualitative research. Within this approach a theory is being derived from findings generated by research. This kind of theory is then called *grounded theory* (Bryman, 2016). A third and more alternative approach is the abductive theory approach. This third approach moves back and forth between theory and research, combining deductive and inductive elements. This would be suitable if the aim of research would be to integrate all possible theories and explanations on the generated results.

The aim of this study to test a specific empirical case through the theoretical *shock event* framework aligns with deductive reasoning where data is used to test a theory (Bryman, 2016). The study starts with established frameworks and concepts and tests their applicability to the Dutch FRM context in the context of the 2021 flood events. Therefore, this study seeks to assess whether observed developments align with theoretical expectations. Nevertheless, this study does contain some inductive elements. The study includes an analysis of pre-event and post-event conditions, and an analysis of the interplay between the dimensions within the framework of Wiering et al. (2018), which indicates the usage of empirical findings to deepen the theoretical understanding, fitting an inductive approach. However, because the core structure tests whether the 2021 flood event meets the established criteria of the frameworks and the *shock event* concept, the research design and form of theory development is best characterised as mainly deductive (Bryman, 2016).

3.3 Methodological choices

The third layer of the research onion entail the methodological choices that are made in the research process. This concerns the choice between quantitative- and qualitative research, or a combination of both. The simplest distinction between quantitative research and qualitative research, amongst many, is the presence and absence of quantifications and measurements (Bryman, 2016). In general, quantitative research entails a deductive approach through testing an existing theory, has incorporated practices of the natural scientific, positivistic, model, and embodies a view of the social world as an external objective reality (Bryman, 2016). On the other hand, qualitative research often takes on an inductive approach and fits better in interpretivism instead of positivism and natural science methods. In addition, it embodies a view of a constantly changing social world, which fits in the ontological assumption of constructionism. In addition, the data collection present major differences. Where quantitative research data exists mostly of numbers and other statistical- or geographical information, qualitative data derives information from words and images (Saunders et al., 2016). It focuses on meanings and interpretations, often with the goal of explaining situations, dynamics, decisions, and so forth. A combination of both is called a mixed-method approach, which combines quantitative- and qualitative techniques within one research (Bryman, 2016).

Since the purpose of this research is to investigate one specific event in a detailed way, including the consequential dynamics of change, this research is considered qualitative research. Moreover, the concepts, variables, and indicators mostly have a qualitative nature. A quantitative research method would definitely not fit the aim of this research since it is not capable of studying dynamics of change at a deeper level.

3.4 Research strategy

This section, representing the fourth layer of the research onion, addresses the research strategy. Saunder et al. (2016) distinguish seven research strategies, but since some of them are solely usable in quantitative research, like the experimental design or survey design, those are excluded from this section. Strategies that can be used in qualitative research are archival research, case studies, ethnography, action research, grounded theory research, and a narrative inquiry (Saunders et al., 2016). These strategies all offer different theory focusses, but only the focus of a case study design fits this research since it includes an in depth-analysis of one specific case. This is very suitable since Stake (1995, cited in Bryman, 2016, p. 66) states that *“case study research is concerned with the complexity and particular nature of the case in question.”*

A distinction of five different types of case studies can be made, which differ in the reason behind the chosen case (Bryman, 2016). The critical case entails a case that is chosen to create a better understanding of when a well-developed theory will hold or not. Secondly, an extreme or unique case represents a case that is not like any other case, creating the opportunity to study unique circumstances. The representative or typical case could contribute to knowledge as an exemplifier. The objective of such a case is to capture an everyday situation. Fourth, a revelatory case includes a new opportunity to study something that was not accessible before. Lastly, Bryman (2016) explains longitudinal cases. These cases offer the opportunity to study one case at two or more junctions, enabling studying changes overtime (Yin, 2009, cited in Bryman, 2016, p. 70).

This case study does not appear to fit a typical case study design, since the focus is on one extraordinary flood event, rather than on routine flood risk management. Secondly, this research does not fit the revelatory case study design, since it does not include access to a phenomenon that was not available before. Thirdly, although this research focusses on a situation before and after an event, a longitudinal design is not suitable because of the cross-sectional design, which will be explained in the next section of this chapter. However, this case study does fit the design of a critical case. By analysing the case the applicability of the term *shock event* to this specific case is tested, making it a critical case for evaluating and potentially extending the FRM theories and frameworks that are used. In addition, the case also has some qualities of an extreme case, since the floods of July 2021 are not considered ordinary in The Netherlands, making it a rare event. This can provide insights into the institutional responses of Dutch FRM to such atypical events.

3.5 Case study selection

The specific case of this research is the major flood event of July 2021, that is studied in the context of Dutch FRM to analyse how this specific flood case acted as a potential *shock event* within the governance context. Within this context the floods are an impactful phenomenon that could catalyse policy change. An explanation of why the Dutch FRM context is chosen, excluding other countries, entails the following. The Netherlands has a unique character in FRM, because of its vulnerability of being largely below sea level (Actueel Hoogtebestand Nederland, n.d.), and its global reputation for flood risk management innovation and knowledge as a consequence (Zevenbergen et al., 2012). This makes it interesting to study how a country with such robust FRM frameworks and advanced flood defences adapts to such an event. Insights that this study provides are therefore relevant for national, but also international FRM. Another practical reason behind choosing the Dutch side of the flood event lays in the heritage and place of residence of the author. Being Dutch makes studying Dutch policy and Dutch actors easier since there is no language barrier, and there is a greater familiarity with the institutional structures. There are four criteria that were used in the process of selecting this case: The case should have experienced a recent flood, it should be a relevant case within FRM, there should be enough policy documents and institutional structures to study, and there should be sufficient potential respondents.

3.6 Time

The fifth layer of the onion concerns the time frame of the research. Saunders et al. (2016) make a distinction between longitudinal research, when events are researched over a given period of time, and cross-sectional design, which means that the research is conducted at one particular moment in time. This research fits in the latter, since it studies one specific event in time, and its consequences, which are also measured at one specific moment, which is 2025. Moreover, this research is time constrained because of the fact that it is performed as a master thesis. The overall time frame of the research is approximately eleven months.

3.7 Techniques and procedures

The last onion in the research onion of Saunders et al. (2016) includes techniques and procedures through which the data collection and -analysis take place. First, this section includes the procedures through which data is collected, after which the data analysis techniques and procedures are discussed. First, multiple sources are used in this case study to ensure triangulation, meaning the usage of more than one method or source of data to cross-check the data to make sure if data is implying what it needs to imply (Bryman, 2016). The facts that are gathered from different sources are able to ensure that potential misstatements are offset (Olsen, 2012).

Data collection

In this study, data are collected through a literature review, a policy document analysis, and semi-structured interviews. The literature review serves as secondary data and provides a conceptual and theoretical foundation. The policy document analysis offers insight in the case context and the factors potentially influencing policy change. The document analysis, together with semi-structured interviews, form the primary data.

Secondary data

Within the literature review, relevant literature is analysed to provide an overview of Dutch FRM and its dynamics. Through an in-depth literature review, an understanding of relevant concepts and the empirical and theoretical context is created. For this review existing scientific research has been used. This data has been collected through the Radboud University Library and other institutions such as governmental organizations and weather agencies. By analysing, for example, documents, reports, and public statements by others, a theoretical basis and empirical context for this research is formed, and an understanding of relevant concepts is created. The sources are mostly qualitative, although some quantitative studies were included to provide a better overview of the whole empirical context of the flood event and its aftermath.

Primary data

The primary data of this study exists of a policy document analysis and semi-structured interviews. For the document analysis policy documents, policy evaluations, flood evaluations, water plans, spatial planning plans were used. The result from this analysis, of in total 20 documents across different governmental levels, generate empirical data about the flood, the aftermath and the governance dynamics involved, which will help answer the research questions. These documents are derived from the electronic databases on governmental websites and websites of other institutions such as a crisis organisation and research institutions as Deltares and HKV, found through Google search. To find these documents a set of inclusion criteria was applied. First, documents had to be available in English or Dutch, as the context is Dutch, and English is the working language of this thesis. Second, no strict publication date was imposed, although preference was given to recent publications. Third, documents were selected based on relevance. To identify sources search terms were used, which are translated here from Dutch to English to improve readability: 'floods of July 2021', 'Limburg floods', 'Dutch flood risk management', 'Floodings in the Netherlands in 2021'. In addition to these searches, a snowballing technique was used during the interviews to identify relevant documents, and reference tracking was performed, whereby documents were traced in previously selected documents. Five of the twenty documents were not read in full, but only partly, because they were either very extensive and/or contained substantial sections that were

not relevant to this study. For these documents, the analysis focused primarily on the summary, and selected sections identified as relevant. The remaining parts were scanned using keywords to locate potential useful information. This approach was applied to documents 1, 3, 8, 11, and 16. The policy documents used for this analysis are listed in table 2 (in their original Dutch names), and their references are included in the reference list at the end of the thesis. In the following chapters, the documents will be referenced to through their document number to improve the readability.

Document number	Name	Author	Year
1a	Voorkomen kan niet, voorbereiden wel	Beleidstafel Wateroverlast en Hoogwater	2022
1b	Wateroverlastbrief	Ministerie van Infrastructuur en Waterstaat	2022
2	Nationaal Deltaprogramma 2025; Naar Een Nieuwe Balans In De Leefomgeving; Ruimte voor leven met water (Headlines)	Deltacommissaris	2024
3	Nationaal Deltaprogramma 2025; Naar Een Nieuwe Balans In De Leefomgeving; Ruimte voor leven met water	Ministerie van Infrastructuur en Waterstaat	2024
4	Rapportage Wateroverlast en Hoogwater	Overlegorgaan Fysieke Leefomgeving	2022
5	Opbouwplan Programma WRL; Gericht aan de slag!	Waterveiligheid en Ruimte Limburg (WRL)	2023
6	Provinciaal Waterprogramma 2022-2027; Cluster Natuur en Water	Provincie Limburg	2021
7a	Omgevingsvisie Limburg	Provincie Limburg	2021
7b	Samenvatting Ontwerp Provinciale Omgevingsvisie Limburg (NL)	Provincie Limburg	2025
8a	Nationaal Waterplan 2016-2021; Verder Met Ons Water	Ministerie van Infrastructuur en Milieu & Ministerie van Economische Zaken	2015
8b	Nationaal Waterprogramma 2022-2027	Ministerie van Infrastructuur en Waterstaat	2022
9	Gevolgen overstromingen Limburg; Inventarisatie en Duiding	Deltares	2023
10	Een Watersysteemanalyse – Wat Leren We Van Het Hoogwater Van Juli 2021?; Inzichten In Het Functioneren Van Beeksystemen Bij Grote Hoeveelheden Neerslag En Het Effect Van Verschillende Typen Maatregelen	Deltares	2023
11	Hoogwater 2021 Feiten en Duiding	Task Force Fact Finding Hoogwater	2021
12	Een Crisis Van Ongekende Omvang; Leerevaluatie Watercrisis Juli 2021	COT Instituut voor Veiligheids- en Crisismanagement	2022
13	De Staat Van Ons Water; Rapportage Over De Uitvoering Van Het Waterbeleid In 2023	Ministerie van Infrastructuur en Waterstaat	2024
14	Evacuatiegedrag van getroffen en tijdens de overstromingen in Limburg in juli 2021	HKV	2022
15	Rampbestrijdingsplan Hoogwater Limburg 2023-2026	Veiligheidsregio Limburg-Noord en veiligheidsregio Zuid-Limburg	2024
16a	Waterbeheerplan 2016-2021; Water in beweging	Waterschap Peel en Maasvallei & Waterschap Roer en Overmaas	2015
16b	Waterbeheerprogramma 2022-2027; Limburgs water in een veranderend klimaat	Waterschap Limburg	2021

Table 2: List of policy documents. Source: own.

Secondly, the primary data exists of in-depth semi-structured interviews. Semi-structured interviews differ from survey research, which relies on standardised, closed questions, often used to generate quantifiable data across large samples (Bryman, 2016). Surveys are therefore not suitable here, as the research aims to gain detailed, context-specific insights in policy change, which require flexible and open-ended responses. On the other hand, semi-structured interviews differ from open interviews since they do not follow any structure. Observation is also not appropriate for this study, since it is typically used to study ongoing social interactions or

behaviours in real time (Bryman, 2016), whereas this study focuses on a past event, for which no relevant setting can be observed directly. In semi-structured interviewing the researcher prepares a set of questions, while holding space for the interviewees to elaborate on their answers where needed. This balance between structure and flexibility ensures a broader, more in depth, understanding of their answers and leaves the possibility to introduce new insights or relevant topics, while also ensuring replicability, and consistency on the topic and across interviews (Bryman, 2016). Therefore, this method is suitable for this study, where certain concepts and theories guide the analysis, but where interviewees' own perspectives and experiences are also important. While a common guide was used across all 15 interviews, the emphasis within each interview varies depending on the interviewees' expertise and role, enabling a more in-depth analysis (Bryman, 2016). The established interview guide for this research is visible in appendix 1. Furthermore, throughout the interview process, continuous reflection was applied to identify which information gaps were left and needed to be addressed in following interviews.

As mentioned, 15 interviews were conducted in total, ensuring a valid data collection, while enabling a rich and in-depth analysis of each interview. With these 15 interviews, the theoretical saturation was considered to be reached. This refers to the moment when no new relevant insights emerge from further data collection (Bryman, 2016). To recruit respondents purposive sampling was used to identify individuals who were likely to provide relevant insights, which were then contacted through email and LinkedIn. In addition, snowball sampling was applied, meaning that initial interviewees were asked to suggest other potentially relevant individuals (Kumar, 2019). According to the used criteria, respondents must be relevant stakeholders in Dutch FRM, or the context of the flood event, they must possess knowledge on FRM in The Netherlands and/or Limburg, and they are able to communicate in Dutch or English. Although interviews could have been conducted in both English and Dutch, all interviews took place in Dutch. These criteria ensured that respondents were directly involved in or connected to FRM and could provide informed reflections on policy processes and the context, rather than general citizen perceptions. Within the selection, attention was also paid to their functions and employers, to create the most inclusive group as possible. The 16 respondents of the 15 interviews are listed below in table 3. The names of Dutch institutions are presented in their original form and language because these are official organisational titles. The functions of the interviewees are translated since those are not official names. In the following chapters, this data will be referenced to through their interview number to improve the readability.

Nr.	Date	Function	Employer	Interview length in minutes
1	11-06-2025	Project Manager Legal Assessment Tools 2023	Rijkswaterstaat	36
2	09-07-2025	Senior Policy Advisor Climate Adaptation & Coordinator Pluvial flooding	Ministerie van I&W	48
3	07-07-2025	Senior Policy Officer Water	Provincie Limburg	47
		Area Manager for the Geul River Basin at WRL	RiHa-Advies BV	
4	02-07-2025	Crisis Management Specialist	Veiligheidsregio Limburg Noord	39
5	24-07-2025	Policy Advisor	Unie van Waterschappen	40
6	25-06-2025	Strategic Policy Officer	Waterschap Limburg	40
7	11-06-2025	Advisor on Rivers, Coasts, and Deltas	HKV lijn in water	50
8	27-06-2025	Coordinating Advisor of the Delta Commission	Deltacommissie, Ministerie van I&W	53
9	10-06-2025	Senior Advisor Participation and Secretary of the Policy Table on high water and flooding	Ministerie van I&W en Overlegorgaan Fysieke Leefomgeving	36
10	04-06-2025	Senior Advisor Flood Risk Management	Deltares	41
11	25-06-2025	Chair and founder of the foundation Waterstop.nu	Waterstop.nu	54
12	05-08-2025	Senior Advisor Water	Provincie Limburg	37
13	25-06-2025	Strategy advisor, Netherlands Programme	WWF-NL	32
14	01-07-2025	Senior Project Manager Blue & Green Economy	Universiteit Wageningen	40
15	20-08-2025	Senior Policy Officer Climate Adaptation in the Built Environment	Ministerie van VRO	41

Table 3: List of semi-structured interviews, sorted by surname of the interviewee. Source: own.

Data analysis

In this study, the analysis follows an analytical deductive strategy, as it tests the existing theoretical framework of factors of stability and change and the *shock event* concept against the empirical case of the 2021 floods. To do this, primary data, the documents and interview transcripts, are manually coded in the programme Atlas.ti. Coding is essential to systematically organise and interpret qualitative data in a consistent and transparent way (Bryman, 2016). In total 15 interview transcripts and 18 policy documents were coded, in addition of two pre-flood policy document versions that weren't coded but were used for comparison. Although this research is primarily deductive, an iterative process between data and theory is maintained. This ensures that emerging insights can refine the interpretation of the theoretical concepts where necessary (Bryman, 2016). Within these processes constant comparison is used throughout the analysis, ensuring that the correspondence between concepts and their indications it not lost. The coding scheme is established through the use of the conceptualization of the concepts, their dimensions, and their indicators, as visible in the codebook in appendix 2.

3.8 Reliability, Replicability, and Validity

In addition to the steps in the research onion, social research knows several evaluation criteria guaranteeing the quality. Three prominent evaluation criteria in social research are reliability, replicability, and validity (Bryman, 2016). Firstly, reliability concerns whether research methods can reproduce the same results multiple times, implying that the measures are consistent, accurate, stable, and predictable. Regarding the interviews of this research the reliability will be ensured through having a consistent interview structure. This will minimise the observer bias and disruption, and it will create consistency in the collected data. However, it must be mentioned that full reliability is hard to achieve in qualitative research because of the subjectivity in data interpretation, participant variability, and researcher bias (Bryman, 2016). These considerations are included through performing the previously mentioned method of triangulation, the participation criteria, and consistent interviewing and coding.

Secondly, replicability ensures the ability to replicate the research. A good replicability can be achieved through a detailed description of each method and step that is performed. For this reason, this criterion is highly valued in quantitative research. In qualitative case study research this is harder to achieve, since the research is very context dependent, the data contains subjectivities, data could be interpreted differently, and grounded theory emphasizes the adaptation of methods based on the data that is collected. However, by documenting every research step, using systematic ways of sampling, triangulating data sources, developing a coding framework, and reflecting, the quality of replication is ensured as much as possible.

Thirdly, Bryman (2016) views validity as the most important research criterion in social research. This criterion implies a good integrity of the conclusions that are drawn from the results. Within validity Bryman (2016) distinguishes four types; measurement validity, ecological validity, internal validity, and external validity, of which only the latter two are relevant for this research. Internal validity concerns the validity of internal causal relationships between variables (Bryman, 2016). In this research, internal validity is ensured through data triangulation, enabling cross verifying the collected data, and through consistent coding, limiting the risk of subjective interpretations.

On the other hand, external validity concerns the generalizability of the results (Bryman, 2016). This is difficult to achieve in a case study design since the results that are derived are very context dependent. However, an option to improve external validity is providing a thick description of the research context to distinguish in what context the results would be generalizable. Secondly, through ensuring a diverse representation of respondents, their different perspectives are included, providing a range of different experiences and insights.

3.9 Ethics

In addition to the quality criteria discussed above, it is essential that any social research is conducted in an ethically responsible way. Bryman (2016) notes that perfectly ethical research is impossible, but researchers should be aware of key principles to make informed decisions. He distinguishes four main areas of ethical principles: harm, informed consent, privacy, and deception. First, researchers must avoid causing harm to participants, including psychological harm such as stress and discomfort. In this study, the interviewees are treated with respect and care. The interviews were scheduled at a time that suited each participant and were conducted via video call, allowing them to speak from a comfortable setting such as their office or home.

Second, informed consent is obtained in this study through providing the respondents with clear information about the aims, procedures, and data usage of this study before agreeing to take part of it. This was done through email and verbally during the interviews before the recordings started. Third, privacy and anonymity are protected through the confidential use of personal data, and the anonymity of the names of the participants. In addition, the data is stored securely and is deleted after the thesis has been finished. Finally, deception is avoided by being honest and open to question and being transparent throughout the whole process

4. Results

The empirical case studied in this research is the governance response to the July 2021 floods in the Netherlands. The flood event is widely described as unpredicted in scale and impact, and provides a relevant case to examine how Dutch flood risk management (FRM) responds to such an extreme flood event, and whether this triggers shifts in policy. By analysing policy documents and interviews this chapter presents the main findings related to the factors of change and stability and the *shock event* concept in the light of the case of the 2021 floods. Each concept is discussed individually, and some of their dimensions are discussed in more detail with their own subheadings, while other less prominent dimensions are discussed briefly in combined paragraphs. This approach was chosen to ensure good readability.

4.1 Shock event

For the first concept of a *shock event*, the used codes in Atlas.ti are visible in the rightest column in table 4, based on the indicators presented earlier in chapter 3.

Shock event	Suddenness / unpredictability	Presence/absence of warning signs
		Time between detection and impact
		Perceived unexpectedness by public or authorities
	(Possible) harm / magnitude	Number of casualties
		Extent of financial damage
		Geographical scope
		Severity of disruptions to infrastructure or services
	Institutional responses	Initiation of policy discussions
		Adoption of new policies or procedures
		Public or political framing of the event as exceptional

Table 4: The conceptualisation of the concept ‘shock event’ into the indicators that were used to code in Atlas.ti. Source: own.

Suddenness and unpredictability

The floods in July 2021 were experienced as sudden and unexpected by institutions as well as citizens. Interviewees from the province, Rijkswaterstaat, the water board, the crisis organisation, the Delta commission, and other relevant stakeholders highlighted three main reasons for this: warnings were late or not taken seriously, the event occurred in summer, and the intensity of the rainfall exceeded all expectations (interview 1, 3, 4, 5, 7, 8, 10 & document 1a, 11).

Regarding the time between detection and impact, although weather forecasts had indicated heavy rainfall about a week before the floods, it was not until the 10th of July that the monitoring guard sent an email to all authorities involved warning them about the urgency of the situation (interview 1,3 & document 12). The first official warning from the weather institute KNMI to the government was given on July the 12th, when code yellow was declared (document 14). On the evening of the 14th of July, this changed to code red, prompting the crisis organisation to warn residents to stay indoors, which left hardly enough time to prepare adequately (document 11, 14). Another factor limiting early detection was the KNMI models' poor capability to estimate water volumes accurately before any precipitation has fallen, making it difficult to predict water flow in advance. Consequently, forecasts underestimated the severity of the rainfall, leading to insufficient warnings (interview 10).

The perceived unexpectedness that followed was evident among both the public and authorities (interview 1, 3, 4, 7, 10 & document 9, 11, 12, 14). Many believed such rainfall would not occur during summer since that had not happened before (document 1a, 11), leaving many, especially in the municipalities along the smaller rivers, unprepared (interview 1, 7). According to a senior advisor on FRM at Deltares, this lack of experience also lowered the citizens' concerns (interview 10, 12). Another aspect contributing to the perceived unexpectedness was the extraordinary quantity of precipitation (document 1a). In short, the combination of inadequate warning signs, the limited time between detection and impact, and a general lack of anticipation and preparations amongst authorities and residents caused the floods to be perceived as sudden and unpredictable. This caused panic, fear, and dangerous situations, requiring the water board to be deployed in 29 of the 31 municipalities (document 12, 14).

(Possible) harm and magnitude

The flooding event has had an effect on a significant geographical scope, containing Belgium, Germany, Luxembourg, and the Netherlands, in which especially the province of Limburg was affected (document 5). The severity in Limburg was amplified by the water flows from Belgium and Germany, creating compounding effects like unobserved levels on the river Maas and its tributaries upstream (Mohr et al., 2023). In Limburg, the floodings moved Northwards, leaving multiple towns along the Geul affected. The high water-level and accumulating waste caused constraints at the Juliana Canal siphon on the Geul, exceeding its capacity and causing the river to flow over (interview 11, 12 & document 10,11). In Valkenburg, water depths reached 1.25m in the city centre, creating serious risks (document 10,11). These impacts and risks illustrate the material and material harm that was or could have been done. Different authorities emphasize that this event had the potential to cause even more damage (interview 1,4,11,13 & document 9).

Concerning the financial damage, an initial quick scan by the Netherlands Enterprise Agency (RVO), commissioned by the Ministry of Justice and Security, provided an estimate of more than 1.8 billion euros of financial damage for the disaster area (RVO, 2021, cited in document 9). Which is expected to be lower if there were more prepare time (document 11). In The Netherlands, the total damage costs for private individuals, businesses, and governmental institutions is being estimated at 433 million euros in the end report of the policy table (document 1). Most damage is thought to have occurred along the River Geul, followed by the river Maas and river Roer, with a limited amount along the Geleenbeek (in the Heerlen region) and in the 'Heuvelland', a region in the south of the Netherlands characterised by a hilly landscape. The highest agricultural damage occurred along the river Maas, where harvests were

considered lost on approximately 40% of the flooded agricultural land (document 11), which is expected to be less in winter times when almost nothing grows (interview 10). Approximately half of the 433 million euros belongs to business interruption and the other half to material damage. A total of 2,300 homes were damaged, 700 of them severely. In addition, 270 catering establishments and 180 shops suffered damage, and around 900 tonnes of household goods were removed (NOS, 2021, cited in document 9). The spatial distribution of the financial damage along the Geuldal are visible in figure 8.

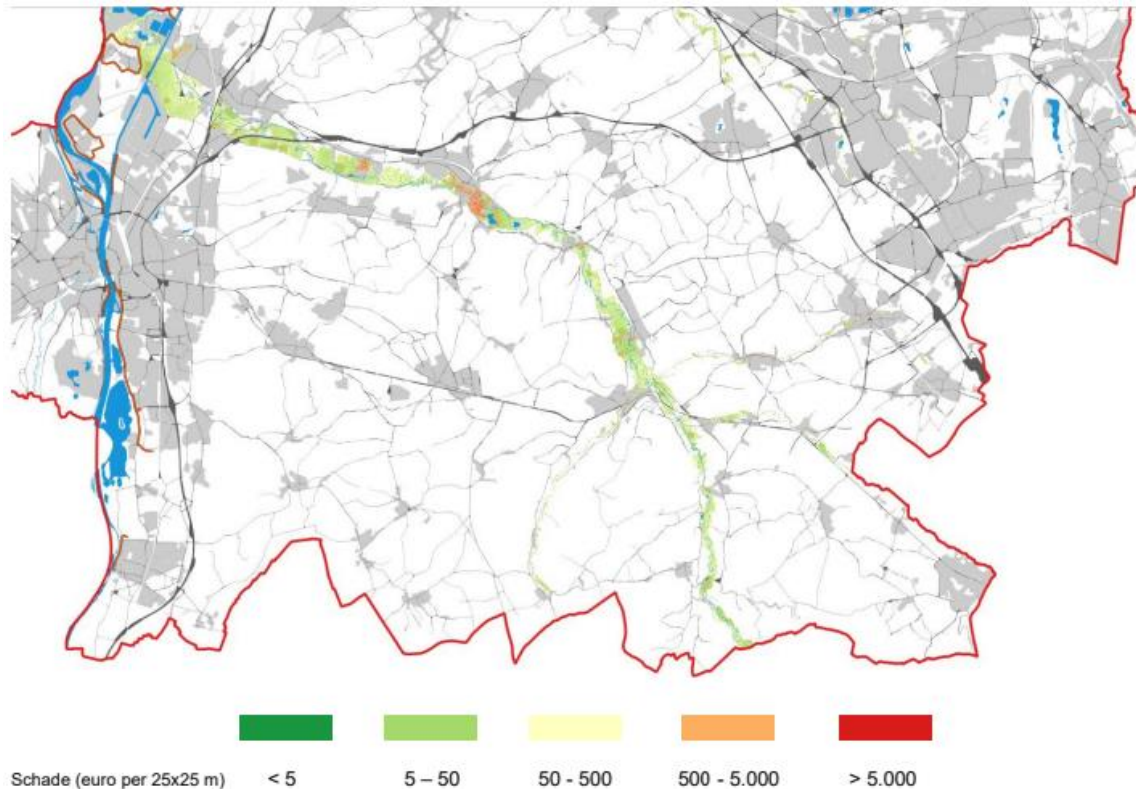


Figure 8: The spatial distribution of financial damage in euro's per 25x25 square meter along the Geuldal. Source: document 9.

When looking at casualties of the floods, thousands of people across the Benelux and Germany were affected. Luckily, the Dutch floods caused no deadly human victims, contrary to Belgium and Germany, where in total more than 200 people died (interview 1,7 & document 1a,11). However, research of knowledge institution Deltares shows that the floods did have the capability to cause fatalities (document 9). Their modelled chances of mortality indicate a zero to one percent of fatality risk in the city of Valkenburg, but risks up to 5 percent near the Geul and in low-lying areas with greater depths and faster rise rates. Causes of flooding fatalities could be undercooling, and wounds or impact caused by objects dislodged by the water (document 11). In addition, research by knowledge institution HKV showed that people were affected heavily in the form of physical and mental illness (interview 7). Examples are psychosocial complaints, bowel problems, and infections (document 11). Especially the psychological complaints were striking, more than half of the population reported significant mental impact.

Severity of disruptions to infrastructure or services

In addition to material and financial damage, the floods caused disruptions to critical infrastructure. The city of Valkenburg, for example, is designed to deal with water nuisance with

a standard of once every 25 years (document 10). However, the city, and many other parts of Limburg, were not prepared for these water-levels, leading to the floodings. Most of the infrastructure disruptions took place in and around Valkenburg and Roermond. The bridge at the Emmalaan in Valkenburg collapsed (document 10, 11), and the floodgates in the city of Roermond broke because of the high discharges due to the combined Maas River and Roer River (document 10, 12). Moreover, major roads such as the A2 and A79 closed for hours or even days, train services across Limburg were temporarily suspended, and river shipping was interrupted due to risks (document 11).

Essential services were also affected. Many institutions or sites had to be evacuated and closed temporarily. Hospitals, hospices, and other care facilities faced operational strains, particularly around Valkenburg and Venlo, where some institutions became unreachable, even for rescue organisations, leaving the already vulnerable residents trapped (interview 4 & document 5, 12). In addition, campsites located in the floodplains were full in the summer, requiring urgent evacuations (interview 4). In total, approximately 50.000 people had been called to evacuate (interview 4). Moreover, approximately 600 businesses experienced service disruption, most of them located along the river Maas and river Geul. Some businesses could open again in a few weeks, while others were closed until January 2022. Another service disruption entails power outages, affecting 6000 to 7000 households for up to several days (document 11). These disruptions highlight the broad operational impact of the flood event across Limburg.

Institutional responses

Policy discussions

After the floods in July 2021, several national institutional discussions emerged about the effectiveness of current Dutch flood risk management FRM; interview 1, 2, 3, 4, 5, 6, 7, 8b, 9, 10, 11, 12, 13, 14 & document 8b, 10, 16). After the floods multiple stakeholders and documents discuss whether you can prepare for such extreme events. The question rises whether we need to come to terms with the fact that that is not possible, and that we cannot keep everyone and every place safe, especially along small rivers. In these cases spatial planning must account for water storage and protection of critical functions (Interview 2, 3, 5, 6, 13).

Secondly, the event triggered national reflection across water boards. According to a strategic policy officer at the Water Board in Limburg “[...] *other water boards are [starting to think] more along the lines of, 'Okay, suppose that happens to us, what are we going to do then?'*” (interview 6, p. 6). According to him, and the coordinating advisor of the Delta Commission, the stress-testing of scenarios similar to the Limburg rainfall in other regions is the start of rethinking our approach for flood preparation on a national level (interview 6, 8). This includes exploring heavier rainfall intensities and multi-day sequences (interview 15). Questions that are posed in this process are: What effects does it have on the area? What are the vulnerabilities? How can you prevent these? (interview 8).

A third discussion point refers to the standardisation of flood risk on a national level (interview 3, 10). These flood standards are established by the provinces and define the acceptable probability of flooding or surface water on the streets, based on in how many years such a flooding is expected and, such as 1/25 or 1/100. The allowed probability differs by region and land-use, reflecting what level of flood risk and investment is considered feasible and reasonable. After the floods some argued that norms such as Valkenburg’s 1/25 norm are too low, especially in comparison to the 1/100 norm in other cities. However, studies show that tightening these norms would require large, landscape-altering measures, such as three meter

high floodwalls. Instead of these large-scale measures, more local, area-specific measures are being explored now (interview 3, 10).

Fourth, debates around system solidarity are intensified, according to a Senior Advisor Water at the Province of Limburg (Interview 14). System solidarity includes compromising in one area to enable another area to reach their spatial planning goals, such as limiting developments. Such integrated spatial decisions require cross-boundary agreements, which is difficult to achieve. The *Waterveiligheid en Ruimte Limburg* (WRL) programme represents a first step towards system solidarity, but according to the Provincial actor “*the proof of the pudding is in the eating*”, and its effectiveness depends on the collaboration between parties (interview 3, p. 13). In addition to the initiated discussions mentioned above, numerous smaller discussions arose, such as the one by Rijkswaterstaat on how to fix the siphon under the Juliana Canal, which got clogged in July 2021 (interview 12).

Adoption of new policies and procedures

The 2021 floodings triggered several institutional changes at different levels. At the national level, the first response was the establishment of a Backoffice of experts of Rijkswaterstaat to coordinate short term development and recovering activities (interview 1). Secondly, KNMI and the water board in Limburg strengthened information services and improved their modelling, including a new ‘flash flood warning system’ (document 1a). Third, the ministry of Infrastructure and Water Management established the policy table *Beleidsstafel Hoogwater en Wateroverlast* to investigate possible lessons from the flooding event (interview 1 & document 4, 8b, 13). As a result, its end report called *Prevention is impossible, but preparation is possible* includes 21 recommendations for all stakeholders involved to work on, ranging from water awareness, improved water management, crisis preparedness, climate-resilient recovery, and cross-border cooperation to increasing knowledge on floodings (Documents 1a, 1b). The 21 recommendations from document 1a, visible in appendix ..., are summarized in seven headlines in document 1b. These headlines are listed in table 5. The recommendations stimulated measures such as public information platforms, like *overstroming.nl*, where citizens can check the flood risk of their neighbourhood (interview 2 & document 1b). Other measures include climate-adaptive housing requirements, the ‘water- en bodem sturend’ approach limiting developments in flood-prone areas, and the ‘building back better’ principle (interview 2, 12, 15).

Number	Headline
1	Everyone water-conscious and self-reliant > through a targeted approach to water awareness
2	Management of the entire river basin > with better sponge effect, more space for and risk-oriented management of the regional water system that feeds into spatial planning and connects to the main water system
3	Additional approach for protection against extreme flooding > An extreme storm such as Limburg 2021 always falls outside the norm, but measures can still limit the consequences.
4	Preparing for a crisis > The possible extent of extreme precipitation is taken into account in crisis management.
5	Climate-resilient repair of damage > If damage does occur, it will be repaired in a climate-resilient manner.
6	Cooperation with neighbouring countries on all cross-border waters > Water does not respect borders, which is why data exchange and a joint regional vision are also needed for the regional water system.
7	Working together smartly and integrally and building knowledge > to be prepared in good time for what is to come.

Table 5: Headlines of the 21 recommendations from the end report of the policy table from document 1a.

One of the most notable national formal policy changes is the expansion of the Multi-Layer Safety approach of the national water plan in 2009 (interview 2 & document 1a,1b, 5). In addition to the existing layers of prevention, spatial planning, and crisis management, the layers of water awareness and recovery were added, as visible in figure 9 below.

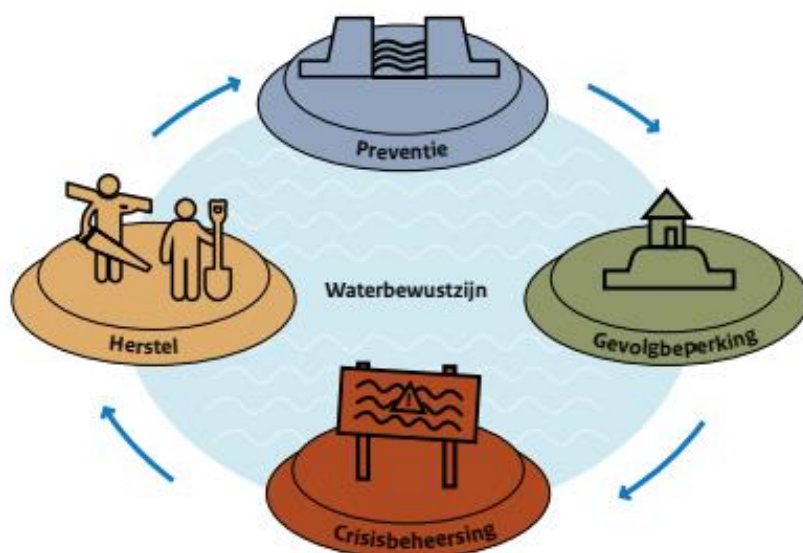


Figure 9: The updated multi level safety approach. Source: Document 1a.

One last adoption on the national level was mentioned by the Coordinating Advisor of the Delta Commission and includes sponge approach. Instead of focusing solely on physical measures, the aim is to let the soil function as a sponge to improve resilience in the case of heavy rainfall, aligning with recommendation 2 of the end report of the policy table (interview 8 & document 16b). Furthermore, in comparing different versions of the National Water Plan, no further adoptions or changes in focus were found (document 8a, 8b). Although it is important to note that the most recent plan is largely written before the flooding event (document 8b).

Moving to the regional level, the *Waterveiligheid en Water Limburg* (WRL) programme was launched, forming a collaboration between the water board, the province, and the municipalities (interview 3). In total it received €600 million of funding, of which €300 million from the national government and €300 million from the region (province, water board, and municipalities; interview 3, 6 & document 5). WRL has three main pillars to reach the climate robustness from the advice of the policy table: through physical measures, through spatial planning, and through creating a more resilient society (interview 3). The first aims to lower the water level at flood prone sites through extra protectional physical measures. The second aligns with the *water- en bodem sturend* principle in spatial planning to enrich water safety. Third, the projects aims at enlarging the self-reliance of residents to limit extreme consequences of water nuisance, like death (document 5). The practical application of each pillar is coordinated per river basin in collaboration with regional project teams (interview 13). This includes measures within the following six categories: retain water (infiltration), store water naturally, store water technically, drain water (remove obstacles/increase capacity), and protect areas (dykes, quay walls, bulkheads) (document 5).

In addition, on the provincial level the 2016-2021 and the 2022-2027 versions of the water management plan of the Limburg water board were compared (document 16a, 16b). Similar to the national water plan, the new version was finished not long after the floods, however the floods did receive attention. A positive note is given to the floodings, because “*The water crisis of July 2021 was the ultimate practical test in which the entire staff of the crisis organisation and all emergency equipment were deployed. We are evaluating this thoroughly.*” (Document 16b, p. 22). On the other hand, they do discuss the urgency of the matter and that “[...] *the images made it clear that controlling such quantities of water requires extremely drastic measures that cost a lot of space and money [...]*”.

Alongside these broader frameworks, operational and procedural changes have been implemented locally. The flood emergency response plan, *Het Rampbestrijdingsplan Hoogwater* (RBP), a plan of the crisis organisation in northern Limburg, is actualised in response to the floods. An Impact Analysis Team is now included to attain information and action plans for the most high-risk streams and tributaries in Limburg (document 15). Furthermore, whereas the water board assessed the compliance of the water system with the standards set out in provincial regulation every six years, from 2021 onwards, they assess cyclically (document 16b). “*This means that each year, part of the management area will be assessed using the most up-to-date data. In this way, the assessment keeps pace with climate change and changes in the water system [...]*” (Document 16b, p. 45). Moreover, many small procedural changes have been implemented at lower institutional levels, like the safety region focusing on improving their imaging in the case of heavy rainfall to improve communication between actors (interview 4).

Despite these steps, interviewees stress that we are ‘just at the beginning’ of implementation (interview 6, 13). Many measures were only starting to be implemented in 2023, or still not enforceable in 2025, such as the adoption of water nuisance in the Delta Programme, which will become definitive next year (interview 8, 13). Meanwhile, some practices remain unchanged, such as rebuilding the damaged infrastructure in the same vulnerable locations due to legal or insurance rules (interview 2).

Public or political framing of the event as exceptional

National and regional institutions consistently framed the 2021 flood event as exceptional. They highlighted that such intense multi-day rainfall had not been anticipated, especially not in summer (interview 1, 4, 10 & document 14). This model exceeding intensity in combination with the season caused many problems such as water behaving differently because of the vegetation, summer recreation along the rivers, and maintenance of water infrastructure (interview 2, 4, 5, 6, 7, 10, 12, 13 & document 1a, 5, 10, 12). The policy table similarly concluded that rainfall risks were larger than previously assumed (document 1), which indicates return periods of once every 500 to 700 years, under the norms of 2021. Moreover, compounding effects amplified risks, such as rapid rises in small streams converging with the river Maas (interview 3, 5). Together, these characteristics support the institutions and experts framing the event as exceptional rather than routine.

The citizens of Limburg also experienced the floods as unexpected and exceptional, partly because the rest of The Netherlands experienced very dry weather (interview 10 & document 2). They reported feelings of surprise, fear, and panic related to the late warnings and perceived inaction (Interview 11 & document 9, 11, 12). For those reasons, the event functions as a so called ‘wake-up call’ underlining the urgency of improving readiness, the warning system, and social resilience (interview 4, 5 & document 1a, 4, 14).

4.2 Factors of change

For the second concept of ‘factors of change’ the used codes are visible in the rightmost column in table 6, based on the indicators presented earlier in the conceptual model.

Factors of change	Actors and coalitions	Entrepreneurs highlighting perception of sub-optimality of governance and approach
		Strong pressure by specific interests (actor coalitions)
	Resources and power	Doubts on increasing costs of flood infrastructure/ maintenance or sudden financial cutbacks, opening alternative options
		New expertise (learning)
	Rules of the game	Decreasing legitimacy of rules
		New rules (e.g. European Floods Directive)
	Policy discourses	Diminishing trust in existing institutions and their efficiency
		New ideas, new problem definitions and policy concepts leading to counternarratives

Table 6: The conceptualisation of the concept ‘factors of change’ into the indicators that were used to code in Atlas.ti. Source: own.

Actors and coalitions

Sub-optimality of governance

The floods in 2021 exposed several shortcomings in Dutch flood risk management. Nationally, the Dutch policy program on major rivers, called *Beleidslijn Grote Rivieren* (BGR), proved itself sub-optimal according to a project manager of Rijkswaterstaat (interview 1 & Ministerie van Infrastructuur en Waterstaat, 2025, cited in interview 1). The BGR was focused mainly on preventing casualties, which was logical in a time where floodplains were largely empty and undeveloped. In the current context, however, many developments are realised on the floodplains, increasing the risk of damage and damage costs. In response, a new policy line was added in the programs’ actualisation to restrict developments and keep the floodplains free as much as possible (interview 1).

At the provincial level, the *Programma Waterveiligheid en Ruimte* (WRL) emphasizes the lack of attention in previous FRM plans to the complexity of the water system in Limburg (interview 3). Therefore, there is no quick fix such as singular, isolated interventions. Particularly in fast-flowing rivers as the river Geul, everything seems to interact, which requires a more integrated basin-wide approach with a broad set of connected measures, including the smaller rivers (interview 3, 5).

Third, the crisis organisation *Veiligheidsregio Limburg-Noord* stresses the lack of clear communication in previous crisis plans (interview 4), causing miscommunications, often caused by incoherence between different forms of communication, a lack of understanding of the imaging by the different parties involved, and fragmented responsibilities across the different parties involved. This sub-optimality is being tackled in the new crisis plans, which are now actualised more frequent in response to the floods. Informing all involved parties and citizens has to become more of a priority, and its coordination must become more central, according to the interviewees (interview 4, 7).

Strong interest pressure

Actors, particularly citizens in Limburg, also created pressure to change through their interests. After the floods, research institutions HKV and Deltares, together with the water board, created an opportunity for the public to express those interests through a public session. Residents were able to pitch their ideas for improving water safety, of which several were adopted in ongoing research and used in informing programs such as WRL and the expanded Multi-Level Safety Approach. This form of participation was much appreciated by the public, and together with the establishment of the citizen-based foundation Waterstop.nu in response to the floods, it shows how citizen interests and pressure arose after the flood event and helped shape post-flood governance directions (interview 6, 10).

Resources and power

Doubts on increasing costs or cutbacks

According to Wiering et al. (2018) another incentive for change are flood protection costs creating doubts and a preference for cheaper alternatives. The interviewees and the analysed documents do not mention such arguments, except for one interviewee, highlighting increasing insurance costs. As mentioned previously, the BGR was updated to include the limitation of damage to the built environment, reflecting a shift in approach to building on floodplains to reduce potential damage costs. The reasoning behind this shift aligns with the aim of minimising rapidly escalating financial losses during or after flood events. Especially since it is complicated to define who should pay for this damage, this is seen as an important incentive to change our perspective on building (interview 1).

New expertise through learning

The Netherlands focusses a lot on systematic learning, meaning that after a flood, not only effort is put in recovering, but also in drawing lessons in order to improve preparedness for future events (interview 1). Post-flood evaluations generated new expertise and insights into interactions between regional, national, and international water systems, leading to cross-provincial stress tests being performed to help identify vulnerabilities and prioritise measures (interview 2, 5, 10 & document 1).

Another concept that increased in attention and implementation scale are Nature Based Solutions (NBS), which prioritise natural over technical measures to battle high water levels and -nuisance. This approach is already adopted in several programs, however, the expertise on the local practice of NBS in Limburg has expanded since the floods. This development also includes cross-border learning as the Dutch authorities exchange expertise with the neighbouring countries of Germany and Belgium in response to the floods. In addition, the Dutch take inspiration from Switzerland to improve the previously discussed risk-based norms for floods (interview 6). Cross-border learning is in line with the sixth headline of the recommendations by the policy table (document 1a).

In addition, on a provincial level, the WRL programme developed new expertise through new advanced models for the Geul, Geleenbeek, and the Roer, supporting scenario-based planning (document 5, 10). As previously discussed, research on the sponge capacity of the soil (*sponswerking*) is also advancing since the floods, contributing to the soil's ability to absorb and retain water, which helps in the case of drought and heavy rainfall (interview 2, 5, 8). This idea is not yet formalised into regulations, but it is gradually becoming more embedded in the National Adaptation Strategy (interview 2). Altogether, this new expertise reflects the learning focused

character of Dutch flood risk management, and a shift towards more integrated nature-oriented governance.

Rules of the game

Reduced legitimacy of rules or models can also trigger policy change. Few interviewees or policy documents relevant to FRM in The Netherlands or Limburg specifically mentioned such a decrease, except for outdated water simulation models and the rules for communication and information sharing during crises. Pre-flood discharge models were not capable of simulating the extreme rainfall observed in Limburg. Therefore, updating these models became a priority in order to improve future predictions and inform investment choices in future FRM (interview 3). Secondly, the communication practices during hazards lost legitimacy by being insufficient and confusing in informing residents and institutions of the expected water levels during the heavy rainfall in 2021. Information provided through the national NLAAlert system, the news, radio, and other unofficial online sources were contradicting, leading to a decrease in satisfaction and trust by the public (document 14). For this reason, the legitimacy of the rules concerning communication during flood events can be considered damaged.

Following decreased legitimacy is the implementation of new rules. The previously mentioned built environment on floodplains that increases damage risks caused those zones to be labelled as H6 zones, indicating that these zones are flood prone and that it is prohibited to build upon them (interview 3 & document 13). This is implemented in the new provincial plan, called the *Omgevingsvisie*, which will be submitted to the provincial council in spring 2026. A second measure that is being legally guaranteed is the national measure for green, climate adaptive built environment, originating in the end report of the policy table and established in March 2023. Every new development must now meet the benchmark in order to develop sustainable and future proof (document 1b). No other actual legislated measures are mentioned in the documents or the interviews that were conducted. However, the Coordinating Advisor of the delta commission did mention that many new measures or changes in policy will be adopted in the Delta Programme in 2027. This is the national legislative framework for FRM, freshwater supply, and climate adaptation, setting strategic directions and decisions for governments, provinces, water boards, and municipalities. The programme reports annually, but the formal embedding of new policies happens on a six year cycle. Therefore, no finalised rules in the Delta Programme can be discussed yet (interview 8).

Policy discourses

Diminishing trust in existing institutions

Although official evaluations show the absence of fatalities and the successes of previous FRM measures, public trust towards institutions and their ability to protect them from future floods has declined, according to multiple interviewees (interview 6, 8). The authorities, such as the province and the water board were perceived as unprepared and uncoordinated during the event, resulting in large-scale evacuations and millions of euros of damage. An example that was given of this unpreparedness took place in the municipality of Meerssen, where emergency services could not respond rapidly and effectively because they were unaware of the location of their own infrastructure when it was submerged under water (interview 11). Adding to this lowered trust, institutions appeared to be evaluated by agencies they had selected themselves, making citizens question the independence of these evaluations (interview 11).

After the floods, the public mistrust was further reinforced by the perceived gap between words and action. Citizens expressed their frustration about the lack of physical results, despite years of plans and programmes that have been established (interview 11, 14). In addition, some citizens have expressed dissatisfaction with the involvement of Rijkswaterstaat and Deltares in post-flood studies, because of potential conflicts of interest, since these institutions are responsible for flood management (interview 7, document 14). At the same time, the local participation session show that citizens are willing to contribute to possible solutions when given space to do so (interview 10).

New ideas, problem definitions and counter narratives

A senior advisor of the Ministry of Infrastructure and Water Management, the Coordinating Manager of the Delta Commission, and the end advise of the policy table declare that the core problem of needing to prevent all flooding has shifted in Dutch FRM in response to the floods to managing flooding impacts when extremes occur, and acknowledging that some things cannot be prevented (interview 2, 8b & document 1a, 1b). This includes a greater emphasis on thinking in extremes and 'what-if' scenarios. The 2021 multi-day heavy rainfall sequence and "*The development of climate data [show] that extreme situations are occurring more frequently and more often.*" (interview 5, 6, 10, 15 & document 5), highlighting the importance of stress-testing, and using floodplains as natural buffers to expand the rivers and lower flood risks and potential damage, according to a Senior Policy Advisor on climate adaptation for the built environment from the ministry of public housing and spatial planning and other interviewees (interview 12, 13, 15).

Secondly, the national problem definition that the secondary rivers are merely a water nuisance problem, made place for integrated management of side- and main rivers (interview 5, document 1). Modelling and evaluations have shown that there is no single fix to such a complex problem (interview 2, 3, 8 & document 1a, 1b), and hard technical measures need to make place for a more integrated solution of this more complex and multi-level problem. In addition, the problem of short intense heavy rainfall has been redefined into multi-day rainfall sequences, which are now being incorporated into standards and stress tests after 2021 (interview 2, 15). Following this shift, Nature Based Solutions (NBS) have gained presence in Dutch FRM, and narratives are moving towards giving rivers more space (interview 3, 5, 12, 15). Only when those solutions are proven insufficient in times of extreme events, they can be combined with targeted hard measures (interview 12, 13). Overall, these shifts appear to be moving from a discourse of prevention towards a more dynamic and integrated form of resilience, generated through a shared feeling of responsibility for preparedness and recovery (interview 2, 5 & document 5).

4.3 Factors of stability

For the third concept of factors of stability the codes are visible in the rightmost column in table 7, based on the indicators presented in the conceptual model.

Factors of stability	Actors and coalitions	Coordination effects: governance is sedimented in specific divisions of accepted responsibilities
	Resources and power	Fixed costs and increasing returns through large investments in flood infrastructure (sunk costs)
		Learning effects: evolution of strong expert body of knowledge and strong epistemic community
	Rules of the game	Law has an important stabilising effect in the formalisation of rules and procedures
	Policy discourses	Strong historical narratives
Adaptive expectations: public trust in existing institutions and their efficiency		

Table 7: The conceptualisation of the concept ‘factors of stability’ into the indicators that were used to code in Atlas.ti. Source: own.

Actors and coalitions

Dutch flood governance is embedded in specific divisions of accepted responsibilities. Although this structure ensure stability and reliability, it also creates coordination effects, which could hinder policy change. Responsibilities within water management are spread across various levels of government, such as national institutions like Rijkswaterstaat, the provinces, water boards, and municipalities, however the responsibility of dealing with floods often depends heavily on local actors (interview 2). This creates inequalities between municipalities, since their resources often differ, and dealing with floods often exceeds their capacities (interview 8).

Another practical tension reinforcing stability can be found in municipalities balancing water management tasks with spatial developments. Although new principles prohibit building on flood-prone areas, the existing built environment and in-practice building plans on these sites make it difficult to enforce these principles (interview 2). This shows, that while the government is taking steps to integrate new water management principles in spatial planning, practical obstacles and a lack of strong legal instruments make the choice to avoid building in flood-prone areas mainly voluntary for municipalities. This hinders their ability to take steps towards risk-sensitive spatial planning (interview 10, 15).

Resources and power

Fixed costs and increasing returns of large investments in flood infrastructure are called ‘sunk costs’, since they stabilise existing approaches. An example in Dutch FRM are the *Maaswerken*, a project along the river Maas where room was made for the water through gravel collection (interview 1). This project is proven successful since the river did not overflow in 2021. Since substantial financial resources have been invested, such large project reinforce commitment and hinder in adaptation and implementing new policies. Especially more classical institutions are limited by their budget, even in the case of floods (interview 9, 13). Fortunately, the WRL programme got its own budget and contributes to adapting after the 2021 floods. However, money often is the biggest limiting factor in changing governance, according to an employee of the water board (interview 13).

Learning effects also reinforce the usage of familiar procedures, limiting the generation of new expertise. As a Senior Advisor on FRM of Deltares noted, “*we know how to do dikes*” (interview 1, p. 5), indicating that procedures for strengthening hard measures are routine in Dutch FRM, and more sustainable innovative solutions like NBS lack established procedures, slowing their adoption (interview 1, 10). No other explicit examples of learning effects were found, although the familiar procedures reinforce the status-quo.

Rules of the game

Laws and regulatory frameworks can also exercise a stabilising effect on policies and strategies. Their formalised and procedural nature ensures consistency, but also hinders development. In Dutch FRM the examples of insurance rules is found. After flood damage, insurance often only covers restorations towards the pre-flood status quo, which lacks flexibility to rebuild more resilient (interview 5, 15). This way, insurance laws keeps recovery within existing standards and discourages improvements, despite the national shift towards building back better.

Land and property ownership forms a second stabilising factor created through law. Many spatial planning and restoration projects are constrained by ownership laws. Authorities can only act on their own land, limiting the ability to implement new measures on a larger scale (interview 13 & document 5). On the other hand, a lack of established legislation can have the same effect. Municipalities often hesitate to approve new adaptive initiatives because there is no explicit policy allowing it, and they are often called back by higher governance levels when they act outside of existing structures (interview 10). This then hinders Dutch FRM in becoming more resilient through new initiatives and measures.

Policy discourses

Despite the new national approach of accepting that not all water nuisances can be avoided because of the increasing effects of climate change, longstanding narratives of the Dutch government being highly protective in FRM continues to shape expectations of other institutions. According to a Senior Advisor from the Ministry of Infrastructure and Water Management this new mindset could take a while to settle in, although such a flood event as in 2021 can help in the process of accepting certain risks, as the realisation that not everything is preventable sinks in (interview 2, 3, 5, 6, 8, document 1a, 1b, 10, 13).

Also the public exercises such expectations, stabilising Dutch FRM. Although not all citizens in Limburg agree, many still have confidence in institutions and their capabilities, because of the ‘exceptional’ character of the event rather than systematic, underlining the assumption that ‘nobody could have predicted this’, which keeps the blame away from institutions. Successful projects as the *Maaswerken* and *Ruimte voor de Rivier* further reinforce such beliefs (interview 12). This enduring trust limits adaptive change, since this way of thinking limits the incentive of institutions and individuals to take responsibility and become more resilient (interview 3, 11). For this reason, a Senior Advisor from Deltares advises institutions to balance promoting self-reliance and raising risk awareness, without creating panic (interview 10).

Finally, the tension between long-term resilience goals and short-term expectations of the public or politicians can hinder policy change, as stated in the WRL programme. Public and political expectations often wish for quick and visible solutions, while this could delay the implementation of the long-term approaches.

5. Discussion of the results

The results from the analysis have shed a light on whether the floods in Limburg in July 2021 can be seen as a *shock event* and how. This chapter provides a critical reflection on the most prominent results and their nuances and significance. By doing so, this chapter aims to form a deeper understanding of what the findings imply about Dutch FRM and the policy response to the 2021 flood event.

5.1 Policy reaction or policy silence?

The floods in Limburg in July 2021 formed a crucial moment in the debate concerning the future of Dutch FRM. Many stakeholders spoke of a ‘wake up call’ in the aftermath of the floods, and the current visions and planned out routes to become climate resilient are considered insufficient in withstanding such events (interview 6, 13 & document 1a, 1b). Nevertheless, the actual policy changes remained modest (Ministerie van Infrastructuur en Waterstaat, 2022; Deltares, 2023). Although the floods temporarily increased attention for climate adaptation, most of the measures continued along existing patterns of dike reinforcement, crisis management, improvements of existing programs such as the *Hoogwaterbeschermingsprogramma* and the *Beleidslijn grote rivieren*. This focus on recovery rather than rethinking illustrates that Dutch FRM tends to absorb shocks rather than rethinking its approach. Therefore, institutions and their measures proved flexible in the technical sense, but rigid in terms of laws and regulation. Kaufmann et al. (2016) describe this as the difference between absorptive and adaptive resilience. Dutch FRM mainly demonstrates the former, absorbing the shock but recovering back to its previous form.

Reasons for this stability are found in the rigid institutional structure of Dutch FRM caused by formalised agreements, legal regulations, and a financial budget (interview 1, 2, 13 & document 5, 13). As Pot, De Ridder, and Dewulf (2024) argue, such structures are known for adopting such events in their approaches, rather than allowing them to reshape those approaches. This aligns with Birkland’s (1998) argument that *shock events* can only trigger substantial policy change when political and institutional conditions allow learning and adapting. In the Dutch case, the mostly unchanged Delta Programme and Water Management Plan of the Water Board Limburg reflect a narrow scope for transformative learning.

Interviewees also emphasize that such adoptions require a long time, since embedded technical measures can not simply be ‘swapped in’ for more integrated adaptive nature-based measures. According to a researcher of the Wageningen University, this process takes many years (interview 2, 4, 14). In short, the formal and procedural nature of Dutch FRM slows innovation in the form of paradigm shifts or structural innovations, such as institutionalising spatial adaptation measures in regulation (interview 2). Leaving us with gradual refinements such as technical and procedural improvements within existing programmes. This lack of actual implementations underlines how policy reactions to the flood event take a lot of time, and when present, they show more of the same, rather than functioning as a catalyst for innovations.

5.2 Stability as a blessing or a curse

An explanation for ‘policy silence’ can be found in the strong institutional character of Dutch FRM, which is often praised as a factor of success (document 4), but also limits the system’s capacity to adapt (Wiering et al., 2018). In Limburg, structural innovations such as formally embedding measures in the provincial plans are still pending or only at the intention stage after four years (interview 2, 10, 13, document 9). As a policy advisor of the Union of Water Boards mentioned “[...] work is still ongoing to implement [the recommendations of the policy table]” (interview 5, p. 4). This can be explained through the rigidity of the accepted division of tasks and responsibilities across multiple governance levels in Dutch FRM. According to Wiering et al. (2018) such coordination, like the *Waterwet*, lead to strong institutional anchoring, making it difficult to redistribute responsibilities or introduce new forms of governance when needed (Schanze, Zeman & Marsalek, 2006). In addition, the maintenance and recovery of existing FRM measures take up a lot of the financial budgets of institutions, leading to a financial scarcity to invest in new adaptive measures. This is in line with the observations by Wiering et al. (2018) that established policy arrangements often resist sudden changes due to their stabilising forces.

At the same time, this same stability is the reason why The Netherlands is relatively well-prepared for heavy rainfall. The robustness and successes of previous measures prevented the floods of 2021 from becoming such disasters as the overflowing of the river Maas in 1993 and 1995 (document 9, 11, 14). Stability therefore offers protection against physical risks, but also hinders the development of new policy ideas. This tension is caused through the stabilising influence of the very features that make systems effective in crisis management and resilience; reliability, hierarchy, and long-term planning (Wiering et al., 2018). This creates a paradox where this successful stability may unintentionally increase the systems vulnerability by limiting institutional learning and adaptation. The question now remains whether Dutch FRM is open to what Folke et al. (2005) call adaptive governance, and what Kaufman et al. (2016) call adaptive resilience. This includes innovating through learning processes and cooperation across institutional boundaries, which the Netherlands aren’t remarkably familiar with (interview 2). Another legislative factor hindering the transition towards this adaptive resilience is insurance, since insurers usually only cover building back to the previous status quo, instead of ‘building back better’ (interview 2, 5, 15 & document 4). These research findings suggest that adaptability is recognised in words, but in practice remains limited by existing structures and a lack of experience in adopting new initiatives (interview 2, 5, 10, 13). Eventually, this reliance on stability may hinder the system to adjust according to changing contexts, acting more like a curse for future proof FRM in The Netherlands (Wierink, Liefferink & Crabbé, 2018; Folke et al., 2005; Kaufmann et al., 2016).

5.3 The missed opportunity of the *shock event*

The flood event in 2021 meets the core characteristics of a *shock event* as defined by Birkland (1998); suddenness, (possible) harm, and the triggering of institutional responses. Due to a short time period between the detection and the occurrence of the floods, and a lack of warning signs, the floods were experienced as sudden by authorities and the public. This challenged existing assumptions of the preparedness of Dutch FRM and local authorities such as the Water Board Limburg and Veiligheidsregio Limburg (interview 7, 11 & document 11). (Possible) harm was evident in the scale of material damage, financial costs (€433 million), evacuations and disruptions to infrastructure and services, and the floods’ potential to cause casualties

(document 1a). The geographical scope of these impacts includes, apart from the neighbouring countries, the province of Limburg, and parts of neighbouring regions (document 5).

Institutional responses followed rapidly with crisis managerial actions, post-event evaluations, and procedural changes, like the establishment of the policy table, and the increased assessments of the water systems in Limburg by the Water Board (document 1, 16b). However, the results show that policy learning only took place to a limited extent. As multiple interviewees mentioned, the cooperation with Germany for example remained mostly at the level of intentions and advice, rather than formalised international agreements (interview 2, 10, 11). This confirms the insights of Wiering et al. (2018) that changes in discourses and mindsets do not always lead to structural changes as long as they are not accompanied by shifts in power or law. Nevertheless, Birkland (1998) states that *shock events* trigger policy change through challenging existing beliefs, which lead to three formalised changes in FRM policy in this case. First, on the national level, the two extra layers of water awareness and recovery are added to the Multi-Layer Safety approach, originating from the advises of the policy table (interview 2 & document 1a, 1b, 5). A second adoption originating from the policy table is the national benchmark *green, climate-adaptive, built environment*, implemented to realise future-roof developments (document 1b). Third, the regional flood disaster response plan (RBP) of Veiligheidsregio Limburg-Noord was updated in response to the floods, including a greater focus on the smaller side rivers (document 15). However, it must be noted that the latter is not particularly a FRM plan, but rather a plan to enact in the case of floods to minimize damage and casualties. Except for these adoptions of policy changes, the effects appeared to stay largely operational: research, improved communication, emergency procedures, and technical quick fixes.

The floods did trigger numerous new discussions and perspectives within Dutch FRM and provincial FRM in Limburg. Summer floods were quite ‘off the radar’ in before 2021, but sparked policy discussions and procedural changes, like year-round readiness in maintenance contracts of Rijkswaterstaat and rethinking when and how bigger constructions can take place without creating a flooding hazard (interview 1). In addition to new discussions, new life has also been blown into old discussions. The floods and the water nuisance are considered an ‘extra drive’, underlining the urgency of existing discussions and plans to reevaluate and implement them more rapidly. Similarly, the concept of Nature Based Solutions was becoming progressively more known, but since the floods and the growing pressure of climate change more attention is being paid to its practical implementation (interview 10, 13, 14). In short, just a few institutionalised formal regulation measures targeting adaptation can be named, leaving many advises, initiatives and intentions unformalized. Without clear mechanisms that turn these reflections into institutional learning and change, such *shock events* remain missed opportunities for becoming more resilient.

5.4 The illusion of resilience

A last reflection targets the way the concept of resilience is being used in Dutch FRM practice. It appears to be the case that it is mainly associated with physical protection to floods, while the original concept explicitly calls for institutional flexibility and the ability to learn and grow (Folke et al., 2005). The illusion that physical resilience, such as taking hard measures, offers safety creates a stable image of FRM policies in The Netherlands. However, since this has proven to lack flexibility, as discussed in previous paragraphs, it is actually quite vulnerable to new types of risks and emergencies, such as the unexpected heavy rainfall in 2021. Schanze, Zeman, and Marsalek (2006) describe this illusion a ‘technocratic illusion’.

Dutch FRM seems to be focussing on improving existing strategies for resilience, such as early warning upgrades with a flash flood system and the cyclical assessments of the water system by the water board (document 1a; document 16b), rather than engaging in actual adaptive resilience and creating new resilience strategies in order to anticipate on unknown future risks climate change will bring (document 10), which contradicts the fifth headline of the recommendations by the policy table about climate-resilient adaption (document 1a). According to a Senior Policy Advisor on climate adaptation from the Ministry of Infrastructure and Water management, a reason for this is that *“In the Netherlands, responsibilities for managing water nuisance are highly institutionalised: provinces set the norms, water boards must meet them, and municipalities operate within these frameworks. This means that the water system is designed to follow existing land-use functions rather than the other way around, which confines problem-solving to the existing system instead of enabling adaptive, forward-looking change.”* (interview 2, p. 6). On the other hand, it must be mentioned that there has been a shift towards creating a more individual public resilience through self reliance, aligning with the first headline of the recommendations done by the policy table (document 1a). This individual resilience is incorporated into the new levels of the multi-level safety approach targeting water awareness, and recovery, which are added to the three layered model from 2009 (interview 8 & document 16b).

In general, the deeply rooted institutional stability of FRM on a national and provincial level, and the focus on taking physical measures in the fields of engineers, hydraulic approaches and weather forecasting, limit its ability to adapt accordingly to the changing context of climate change in The Netherlands and Limburg (interview 1, 10 & document 5). Together with accepted responsibilities, this causes policy reactions to stay focused on technical optimisation and procedural changes of existing measures, rather than the structural adoption of adaptive measures (interview 2). Only when this problem is tackled and space and procedures are established on how to become more adaptive, Dutch FRM can take steps towards adaptive governance and resilience to climate change, preventing flood risks in the future.

6. Conclusions

This chapter presents the most significant findings of this research by answering the sub-questions, and the main research question: *‘Did the July 2021 flood event in The Netherlands act as a shock event that triggered policy change in Dutch flood risk management and how?’*.

6.1 Sub-question 1

The first sub-question *Can the flood event of July 2021 be considered a shock event?* focuses on the applicability of the *shock event* theory of Birkland (1998) on the floods in Limburg in 2021. The analysis demonstrates that the 2021 floods in Limburg display several key characteristics of a *shock event*, as defined by Birkland (1998). The heavy rainfall and the consequential floodings occurred suddenly, caused extensive harm through material, financial, and psychological damage, and triggered policy reactions. As stated by interviewees as well as in the analysed documents, the unexpectedness was perceived by both authorities and the public, as the rainfall exceeded all existing measuring norms and expectations, in combination with a lack of warning signs and time between detection and flooding. Secondly, the large scale evacuations,

the damage to infrastructure such as bridges and service buildings, and the estimated economic losses of €433 million show the substantial disruption that was caused and harm that was done. In terms of institutional responses, the event was framed as exceptional and triggered many discussions to arise, or old discussions to be revived again, and all interviewees have agreed of the flooding event being a *wake-up call* for Dutch flood risk management (FRM). The flood event has also led to the adoption of new policies, including the two new layers in the multi-level safety approach on a national level, the new benchmark called *green, climate-adaptive, built environment* on a national level, and the update of the flood disaster response plan of the crisis organisation of Limburg North. Although the latter is not a plan to minimize flood risk, but rather to act after the occurrence of a flood. Next to these policies, only advises, recommendations and intentions that have not (yet) been formalised were established after the floods. Overall, these findings confirm that the flood event in Limburg in 2021 can be regarded as a *shock event* in the Dutch context, capable of challenging existing assumptions and triggering policy change in FRM. How the flood events lead to the few formalized policy changes will become clear in discussing the following sub-questions.

6.2 Sub-question 2

The second sub-question *What were the main factors that contributed to policy change after the floodings of July 2021?* examines which factors contributed to policy change after the flood event. Since the floods were widely declared a *wake-up call*, authorities began reevaluating policies and procedures on the national, regional, and local level. In this evaluation several sub-optimality of former governance, regulations, and measures were highlighted. A governance sub-optimality was the lack of attention for the smaller side rivers in flood protection measures, and the focus of the Dutch policy program called *Beleidslijn grote rivieren (BGR)* on solely preventing victims, instead of including damage. Other examples include ways of communication and water level models that were proven inefficient. These sub-optimality have, in combination with the public pressure to move towards better water safety, triggered new discussions, and in some cases even the adoption of new policies, as discussed above. In terms of resources and power, the event led to temporary political attention and fundings, the *Waterveiligheid en Ruimte Limburg (WRL)* programme being the biggest example with a funding of €600 million. This funding was half provided by the national government and half by the regional government and water board. These resources enabled research and cross-border collaborations generating new expertise that might not have occurred without the post-flood momentum.

Overall, previous FRM was proved to be unprepared for such heavy rainfall as in 2021. This led to re-evaluations, declining public trust in authorities and their capacity to protect them from future floods, and investments in recovery and research. This led to new ideas and a new problem definition. Interviewees described a shift from the long-standing goal of trying to prevent all floods, towards accepting that not everything is preventable, and managing flood impacts when extremes occur. In this approach resilience must be built through awareness, preparedness, and the capacity to 'build back better'. In line with this shift, nature-based-solutions and other climate adaptive solutions gained attention. Together, the recognised weaknesses, declining public trust, new ideas and knowledge, provided funding, and new problem definitions collectively contributed to policy change. Therefore, when looking at the article of Wierink, Liefferink & Crabbé (2018), it can be concluded that their established factors of change are present in Dutch FRM after the flood event of 2021.

6.3 Sub-question 3

Despite these factors stimulating change, the third sub-question, *What were the main stabilising factors hindering policy change after the floodings of July 2021?*, seeks to discover which factors in the policy context of FRM in The Netherlands, and on a smaller scale in Limburg, contributed to stability after the floods, limiting policy change. Similar to the factors of change, the stability and change framework of Wierink, Liefferink & Crabbé (2018) is used to analyse the factors contributing to policy change.

First, the institutional structure in Dutch FRM is revealed to be deeply rooted, characterised by hierarchy, a focus on technical expertise and measures, long-term planning, and accepted responsibilities. These characteristics reinforce the status quo in water management and the current focus on physical protection measures. On the one hand, this stability appears to ensure reliability and successes of flood protection and maintain public trust, but on the other hand it restricts authorities from learning and adopting new policies and initiatives. In contrast with the positive effects of funding, resources and their regulations can also have stabilising effects. Compensation and insurance arrangements are primarily designed to restore pre-flood conditions, discouraging adaptive resilience and new initiatives. An interviewee mentioned that another way in which regulation had a stabilising effect on FRM in Limburg is that it is difficult to deal with, and approve, new initiatives from society or other organisations, as we no longer know what to do if there is no policy in place. In this case, the lack of regulation plays the limiting factor. Moreover, the public trust in the Dutch water management system also contributes to policy stability in Dutch FRM. The Netherlands' strong history of successful flood protection created a strong belief in the reliability of existing policies and authorities and their capabilities. As several interviewees mentioned, both citizens and local officials often feel 'taken care of' concerning flood safety, which diminishes societal urgency to act themselves. In conclusion, these stabilising factors of embedded institutional structures, the dominance of technical measures, rigid financial frameworks, and high public trust created a path of continuity for Dutch FRM and limited the ability of this system to adapt to new challenges and contexts. This tension between reliability and rigidity shows the paradox of stability, where the strengths of the system limit it to adapt, causing it to become weaker in the case of a changing context.

6.4 Sub-question 4

To answer the fourth sub-question *What policy lessons could be drawn from the Dutch flood risk management response to the flood event of July 2021?*, a set of practical lessons were found in the results, originating from direct arguments of the interviewees, and from how policies and policy documents were actually adjusted. Three key lessons for Dutch flood risk management (FRM) came out strongest: the need to accept residual risk, the need to think in extremes, and to keep floodplains free from building developments.

The lesson that was emphasized the most by the interviewees and in the documents includes that authorities, and society, need to start accepting residual risk. The floods demonstrated that even high-functioning FRM systems as the Dutch system can be overwhelmed, and that the idea of full safety is unrealistic. Rather than trying to prepare and promise full flood prevention, like done before 2021, it is needed to prepare for impacts, including public acceptance of this risk, changing plans accordingly, and loosening funding and insurance regulation in order to create opportunities for new initiatives. The Dutch absolute protection is no longer suitable, and the

guiding principle should be *Voorkomen kan niet, voorbereiden wel*, which means Prevention is impossible, but preparation is possible, also the title of the end advice of the policy table. This lesson is already visible in the expansion of the multi-layer safety approach, which now contains two extra layers of awareness and recovery.

Secondly, multiple interviewees underlined the urgency of thinking in extremes and ‘what-if’ scenarios since this flood event exceeded all the models and expectations. Before 2021, there was a general assumption that such heavy rainfall would only occur in winter and would only cause problems on the main rivers. The 2021 flood event has proven otherwise through high water levels in summertime in both the main rivers and the smaller side rivers. According to the interviewees, authorities should plan for such surprises through stress-testing beyond the norms and evaluations of previous floods. Another factor of surprise in 2021 that must be considered in future testing is the endurance of the precipitation, which highlights the need for multi-day rainfall sequence testing. These evaluations and tests ask for a learning-oriented approach outside of our current ways of thinking.

Third, a lesson could be learned in the field of spatial planning in order to improve FRM, according to multiple interviewees. The flood event demonstrated that it is necessary to restore and maintain floodplains as natural buffers, keeping them free from developments. This would lower flood risks and damage, and increase their capability to store water. Moreover, this lesson highlights the role of spatial planning in FRM. In the built (flood plain) area, hardened surfaces accelerate runoff, worsening peak flows in the occurrence of extreme rainfall. This stresses the importance to integrate strategies or policies to keep such areas free of developments.

Together, these lessons show the shift that is needed from trying to control water, to managing uncertainty and living with water in a changing climate context. These lessons are not merely technical; they demand institutional and spatial shifts rather than improvements of technical measures. Therefore, these lessons point towards a more adaptive and integrated flood governance approach that acknowledges the limits of control and embraces learning and adapting in order to be as resilient as possible for future extremes.

6.5 Answering the main research question

The flooding event in Limburg in July 2021 caused by a multi-day sequence of heavy rainfall did function as *shock event*, by using the definitions of a *focusing event* by Birkland (1998), and triggered policy change to happen in the context of Dutch flood risk management (FRM). The event fulfilled the main criteria of a *shock event* because of its sudden, exceptional, harmful character and its ability to trigger policy change. The floods challenged the existing assumptions of flood management and flood safety and stimulated debates on the adequacy of Dutch FRM. These discussions led to new ideas and three main lessons: accepting residual risks, preparing for extremes, and implementing spatial planning measures to keep the floodplains free to increase flood safety. In order to perform a thorough evaluation and establish central recommendations for all institutions involved, the policy table *Beleidsstafel Hoogwater en Wateroverlast* was established on behalf of the Department for Infrastructure and water management, which led to a list of 21 recommendations. Following these recommendations, several policy changes occurred. The multi-level safety approach gained the levels of awareness and recovery, aiming towards a more resilience FRM and society. Secondly, the national benchmark *green, climate-adaptive built environment* was established in order to guarantee climate adaptive spatial developments. Third, the flood disaster response plan (RBP)

of the crisis organisation of Limburg North was updated, although this is a plan focusing on managing the crisis of a flood and not the initial flood risk.

The mechanisms through which the flood event triggered change are primarily related to increased public and political attention, the identification of governance weaknesses through evaluations and the public, and the availability of financial resources in the shape of funding. The flood event exposed the limitations of Dutch FRM in the context of extremes caused by climate change. The focus before 2021 laid mainly on technical flood defences and warning systems, and it lacked awareness, cross-scale coordination, and preparedness for such a flood. Simultaneously, these sub-optimalties and the discussions previously mentioned led to a shift in the dominant FRM discourse of flood prevention towards flood impact management, and towards a growing awareness that the residual risks of floodings must be accepted since a total prevention of floods is impossible. This reflects a broad paradigmatic shift in the way of thinking in Dutch governance.

Despite these implementations and the mindset shift that has been triggered, the capacity of this event to trigger structural policy change has so far remained limited. The changes that have occurred stay within the structures of existing policies and appear to stay mainly operational in the forms of improved communication, improved emergency procedures, and quick technical fixes in order to recover after the damage that has been done by the floods. Several stabilising factors play a role in this limitation. The Dutch FRM landscape has created a path of continuous reliability, hierarchy, and accepted responsibilities across different governance levels. Financial- and insurance regulations still focus on recovery in the form of reestablishing the pre-flood situation, instead of recovery in an adaptive way, like the *building back better* approach. In addition, the long-standing trust of the public and local organisations on the government to keep them safe from floods shows the limited awareness and urgency to contribute to solutions. These stabilising factors contribute to the tension creating the paradox of Dutch FRM being strong and efficient through rigidity and reliability, but limiting itself to adapt to future changes through these exact same characteristics.

In conclusion, the 2021 flood event can be considered a *shock event* that triggered policy change in Dutch FRM to some extent. The event helped spark discussions, leading to a shift in the mindset of Dutch FRM, the establishment of recommendations and lessons for future FRM, and a greater awareness of the extreme climate change events that could occur. Integrating and formalising this requires more adaptive thinking and planning, which is a long-going institutional process. The true and final impact of this shock will depend on whether the main lessons and recommendations will be further translated into institutional frameworks in Dutch FRM in a way that increases the adaptivity of the system to prepare for the future context of climate change.

7. Reflection and further research

In this final chapter a reflection of the performed study will be given, together with recommendations for future research. The reflections section starts with an evaluation of the research methods used, followed by an evaluation of possible limitations on the theories that are used.

7.1 Reflections

Reflection on the research methods

This research is performed through a case study with a qualitative research design that consists of a document analysis of 20 documents, and fifteen semi-structured interviews. Given the complexity of the context in which the governance reactions to the flood event in Limburg took place, this combination of methods and the case study design proved suitable. The semi-structured interviews enabled an in-depth analysis of experiences and interpretations of actors across multiple governance levels, ranging from national, to provincial, to local institutions. Speaking to fifteen different respondents with varying functions and expertise strengthened the internal validity, and deepened the understanding of the findings. A limitation of the interview process entails that not all perspectives may be represented. Although attention is paid to select representative, relevant actors without excluding people, it is impossible to guarantee full inclusion in purposive selection and the usage of ‘snowballing’, particularly since not all potential respondents are easy to reach or directly involved.

The document analysis complemented the interviews through providing insight in the empirical context, governmental responses, and how these positioned themselves opposed to pre-flood measures. On the other hand, this method has the limitation that it tends to show official narratives and intentions, rather than what actually happens in practice. Especially since documents only represent one specific moment in time, while practice changes continuously. Another limitation relates to the timing of this study, since not all expected institutional changes have been finalised yet, as mentioned by multiple interviewees. Such implementations, especially of laws, take many years. This indicates that when performing similar research again after a few years could lead to different results. Moreover, it must be noted that the findings of this research are not very generalisable since it is a case study of one specific event in one country with many case-specific characteristics and circumstances.

Reflection on the theoretical framework

The basis of this thesis is found in the factors of stability and change theory of Wiering et al. (2018), and the literature on *shock events* by Birkland (1998). This combination proved useful in understanding the effects of the 2021 flood event in Limburg within Dutch flood risk management (FRM). While Birkland’s (1998) insights helped in discovering the event’s policy triggering capabilities, the stabilising, and change-promoting factors from the first theory helped understanding the extent in which these changes actually took place within Dutch FRM. However, a limit of the theory of factors of change and stability can be that it is not as functional in explaining why certain factors are more dominant than others, leading to a specific policy outcome. As a result, it can be stated that the findings required some own interpretation of the researcher, which could have led to subjectivity. Overall, the chosen theoretical framework

provided a structured basis for the analysis, but future research could benefit from implementing more frameworks and theories on why certain actors or factors are more dominant than others, influencing the outcomes.

7.2 Recommendations

Based on the findings in this thesis, several recommendations for future research on Dutch FRM can be made. Because the results show that the implementation of changes into formalised measures or laws is a still process. Therefore, it is likely that not all new ideas or changes have been incorporated in contemporary policy. Studies with a longitudinal design, could offer insights in how new ideas evolve over time, and in what context they lead to actual policy change. Even a cross-sectional study in five to ten years, when the new Delta Programme is finalised, could help in gaining more knowledge on what ideas actually become institutionalised, and what ideas lose attention or urgency. Within this process, the influence of the stabilising factors could be researched more extensively, which could contribute to determining which factors are dominant in hindering policy change, and therefore have the highest priority to tackle them.

A second recommendation concerns the governmental level at which this research took place. While this study focuses on the national, regional, and local context, it has been discussed how municipalities play a key role in the eventual practice of FRM. Future research could therefore examine the role of this governmental level more closely to see in what ways the local circumstances actually shape the outcomes of initiated policy change.

Third, as mentioned in the introduction, the context of the neighbouring countries of The Netherlands have not been included in this research. Although this way a more detailed understanding of the national governance structure was reached, water does not stop at borders, and a cross-border approach could help in understanding water flow dynamics on a larger geographical scale, which could potentially contribute to becoming more resilient to worldwide climate change.

Finally, several interviewees mentioned the importance of the individual and societal resilience, but no citizens were included in this research, except for what is stated about them in existing literature and policy documents. If these forms of resilience really are able to make a difference in the preparedness of FRM to future climate change events, everyone could benefit from further research on contributing and limiting factors of such resilience in the case of such extreme flooding events as the 2021 floods. In addition, combining the more institutional analysis with such a societal approach could offer a more complete image of how FRM is experienced by authorities as well as the public.

References

- Actueel Hoogtebestand Nederland (n.d.) *AHN Viewer* [online] <https://www.ahn.nl/ahn-viewer> (Consulted on January 20, 2025).
- Ansell, C. (2022) Introduction to the Handbook on Theories of Governance. In *Edward Elgar Publishing eBooks*. <https://doi.org/10.4337/9781800371972.00007>
- Arnell & Gosling (2014) The impacts of climate change on river food risk at the global scale. *Climatic Change*, 2016(134), 387-401.
- Arnell, N. W., & Gosling, S. N. (2014) The impacts of climate change on river flood risk at the global scale. *Climatic Change*, 134(3), p. 387–401.
- Asante, W. (2023) The multiple streams framework and forest policy change process in Ghana. *Cogent Social Sciences*, 9(1), Article 2228062
- Beleidsstafel Wateroverlast en Hoogwater (2022) *Voorkomen kan niet, voorbereiden wel*. Ministerie van Infrastructuur en Waterstaat [document 1a].
- Birkland, T. A. (2006) *Lessons of Disaster: Policy Change after Catastrophic Events*. Georgetown University Press.
- Birkland, T.A. (1998) Focusing Events, Mobilization, and Agenda Setting. *Journal of Public Policy*, 18(1), p. 53-74.
- Bosoni, M., Tempels, B., & Hartmann, T (2021) Understanding integration within the Dutch multi-layer safety approach to flood risk management. *International Journal of River Basin Management*, 19(2), p. 81-87.
- Brimblecombe, P., Hayashi, M., & Futagami, Y. (2020) Mapping Climate Change, Natural Hazards, and Tokyo's Built Heritage. *Atmosphere*, 11(7), 680.
- Bryman, A. (2016) *Social research methods* (5th edition). Oxford: Oxford University Press.
- Cash D. W., Clark W.C., Alcock F., Dickson N.M., Eckley N., Guston D.H., Jäger J., Mitchell R.B. (2003). Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences of the United States of America*, 100(14): 8086–8091.
- CDP (2024) *Europe Floods* [online] <https://disasterphilanthropy.org/disasters/2024-central-and-eastern-europe-floods/> (Consulted on November 26, 2024).
- Copernicus (2021) *Flooding in Europe* [online] <https://climate.copernicus.eu/esotc/2021/flooding-july> (Consulted on November 25, 2024).
- Copernicus (2023) *Flooding* [online] <https://climate.copernicus.eu/esotc/2023/flooding> (Consulted on November 26, 2024).
- COT (2022) *Rapportage Leerevaluatie Hoogwater Maas en Roer*. Multidisciplinaire crisisorganisatie Veiligheidsregio Limburg-Noord.
- COT Instituut voor Veiligheids- en Crisismanagement (2022) *Een Crisis Van Ongekende Omvang: Leerevaluatie Watercrisis Juli 2021*. Roermond: Waterschap Limburg [document 12].

- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE Publications.
- Deltacommissaris (2024) *Nationaal Deltaprogramma 2025; Naar Een Nieuwe Balans In De Leefomgeving: Ruimte Voor Leven Met Water, Hoofdlijnen*. Den Haag: Rijksoverheid [document 2].
- Deltares (2023a) *Gevolgen overstromingen Limburg; Inventarisatie en Duiding*. Delft: Deltares [document 9].
- Deltares (2023b) *Een Watersysteemanalyse – Wat Leren We Van Het Hoogwater Van Juli 2021?; Inzichten In Het Functioneren Van Beeksystemen Bij Grote Hoeveelheden Neerslag En Het Effect Van Verschillende Typen Maatregelen*. Delft: Deltares [document 10].
- Deltares. (2023) *Gevolgen overstromingen Limburg: Inventarisatie en duiding* (No. 11207700-007-ZWS-0011). Waterschap Limburg.
- Desmet, K., Kopp, R.E., Kulp, S.A., Nagy, D.K., Oppenheimer, M., Rossi-Hansberg, E. & Strauss, B.H. (2018) *Evaluating the economic cost of coastal flooding* (Working paper No. 24918) National Bureau of Economic Research.
- ECMWF (2021) *Extreme rain in Germany and Belgium in July 2021* [online] <https://www.ecmwf.int/en/newsletter/169/news/extreme-rain-germany-and-belgium-july-2021> (Consulted on November 25, 2024).
- Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources*, 30, 441–473.
- Geels, F. W., & Schot, J. (2007) Typology of sociotechnical transition pathways. *Research Policy*, 36(3), p. 399–417.
- Glaus, A., Gavilano, A., & Ingold, K. (2024) Under which conditions do extreme events support a paradigm shift? Studying focusing events during two centuries of Swiss flood risk management. *Regional Environmental Change*, 24(162).
- Gleick, P.H. (2010) Climate change, exponential curves, water resources, and unprecedented threats to humanity. *Climatic Change*, 100, 125-129.
- Harris, S. A. (2010) *Global Warming*. SCIYO Croatia, pp. 159-220.
- HKV (2022) *Evacuatiedrag van getroffen tijdens de overstromingen in Limburg in juli 2021*. Lelystad: Rijkswaterstaat. [document 14].
- Holmes J, Clark R. (2008) Enhancing the use of science in environmental policymaking and regulation. *Environmental Science and Policy*, 11(8): 702–711.
- Janse G. (2008) Communication between forest scientists and forest policymakers in Europe – A survey on both sides of the science/policy interface. *Forest Policy and Economics*, 10(3): 183–194.
- Kasperson RE, Berberian M (2011) *Integrating Science and Policy: Vulnerability and Resilience in Global Environmental Change*. Earthscan Publications: London.
- Kaufmann, M., Lewandowski, J., Choryński, A., & Wiering, M. (2016) *Shock events, and flood risk management: a media analysis of the institutional long-term effects of flood events in the Netherlands and Poland*. *Ecology and Society*, 21(4).

- Kaufmann, M., Lewandowski, J., Choryński, A., & Wiering, M. A. (2016) *Shock events and flood risk management: A media analysis of the institutional long-term effects of flood events in the Netherlands and Poland. Ecology and Society, 21(4)*, Article 51.
- Kousar, S., Afzal, M., Ahmed, F., & Bojnec, Š. (2022) Environmental Awareness and Air Quality: The Mediating Role of Environmental Protective Behaviours. *Sustainability, 14(6)*, 3138.
- Kron, W. (2002) Keynote lecture: Flood risk = hazard x exposure x vulnerability. In: Wu et al. (eds), red., *Flood Defence*. New York: Science Press, 82-97.
- Kumar, R. (2019) *Research Methodology: A Step-by-Step Guide for Beginners* (5th edition).
- Lehmkuhl, F., Schüttrumpf, H., Schwarzbauer, J., Brüll, C., Drietze, M., Letmathe, P., Völker, C. & Hollert, H. (2022) Assessment of the 2021 summer flood in Central Europe. *Environmental Sciences Europe, 34(107)*, 6.
- Liefferink, D. (2006) The dynamics of policy arrangements: Turning round the tetrahedron. In B. Arts & P. Leroy (Eds.), *Institutional dynamics in environmental governance* (pp. 45–68). Springer.
- Magnuszewski P, Sodomkova K, Slob A, Muro M, Sendzimir J, Pahl-Wostl C. (2010) *Report on conceptual framework for science–policy barriers and bridges*. In Final Version 22.12.2010 of Deliverable No. 1.1 of the EC FP7 project PSI-connect. EC contract No. 226915. July 2010, Delft, the Netherlands.
- Manandhar, B., Cui, S., Wang, L., Shrestha, S. (2023) Post-Flood Resilience Assessment of July 2021 Flood in Western Germany and Henan, China. *Land, 12(625)*, 32.
- Melnikovas, A. (2018). Towards an explicit research methodology: Adapting research onion model for futures studies. *Journal of Future Studies, 23(2)*, p. 29–44.
- Ministerie van Infrastructuur en Milieu & Ministerie van Economische Zaken (2015) *Nationaal Waterplan 2016-2021; Verder Met Ons Water*. Den Haag: Rijksoverheid [document 8a].
- Ministerie van Infrastructuur en Waterstaat (2022) *Maatregelen tegen overstromingen* [online] <https://www.rijksoverheid.nl/onderwerpen/water/maatregelen-tegen-overstromingen> (Consulted on January 22, 2024).
- Ministerie van Infrastructuur en Waterstaat (2022a) *Wateroverlastbrief*. Den Haag: Rijksoverheid [document 1b].
- Ministerie van Infrastructuur en Waterstaat (2022b) *Nationaal Waterprogramma 2022-2027*. Den Haag: Rijksoverheid [document 8b].
- Ministerie van Infrastructuur en Waterstaat (2023). *Actualisatie Beleidslijn Grote Rivieren* [online]. Rijkswaterstaat. <https://www.rijksoverheid.nl/documenten/rapporten/2023/09/27/actualisatie-beleidslijn-grote-rivieren>
- Ministerie van Infrastructuur en Waterstaat (2024) *De Staat Van Ons Water; Rapportage Over De Uitvoering Van Het Waterbeleid In 2023*. Den Haag: Rijksoverheid [document 13].
- Ministerie van Infrastructuur en Waterstaat (2024) *Nationaal Deltaprogramma 2025; Naar Een Nieuwe Balans In De Leefomgeving: Ruimte Voor Leven Met Water*. Den Haag: Rijksoverheid [document 3].
- Ministerie van Verkeer en Waterstaat (2009). *Nationaal Waterplan 2009–2015*. The Hague: Ministerie van Verkeer en Waterstaat.

- Ministerie van verkeer en waterstaat (2010) *Ruimte voor de Rivier* [online] <https://geografie.nl/sites/default/files/paragraaf/attachment/file/Van%20Dijk%20-%20Ruimte%20voor%20de%20Rivier.pdf> (Consulted on January 5, 2025).
- Mohr, S., Ehret, U., Kunz, M., Ludwig, P., Caldas-Alvarez, A., Daniell, J.E., Ehmele, F., Feldmann, H., Franca, M.J., Gattke, C., Hundhausen, M., Knippertz, P., Küpfer, K., Mühr, B., Pinto, J.G., Qunting, J., Schäfer, A.M., Scheibel, M., Seidel, F. & Wisotzky, C. (2023) A multi-disciplinary analysis of the exceptional flood event of July 2021 in central Europe – Part 1: Event description and analysis. *Natural Hazards and Earth System Sciences*, 23, 525-551.
- Najibi, N. & Devineni, N. (2018) Recent trends in the frequency and duration of global floods. *European Geosciences Union*, 9(2), p. 757-783.
- National Levee Database (n.d.) *About Flooding* [online] <https://levees.sec.usace.army.mil/flood-basics/about-flooding/> (Consulted on November 25, 2024).
- New York Times (2021) *Hundreds Missing and Scores Dead as Raging Floods Strike Western Europe* [online] <https://www.nytimes.com/2021/07/15/world/europe/flooding-germany-belgium-switzerland-netherlands.html> (Consulted on November 25, 2024).
- NOS (2021) *400 miljoen euro schade door overstroming Valkenburg, 2300 huizen beschadigd*. [online] <https://nos.nl/artikel/2390198-400-miljoen-euro-schade-door-overstroming-valkenburg-2300-huizen-beschadigd> (Consulted on November 25, 2024).
- Olsen, W. (2012). Case-study research. In *Data Collection: Key Debates and Methods in Social Research* (pp. 183–185). SAGE Publications Ltd.
- Overlegorgaan Fysieke Leefomgeving (2022) *Rapportage Wateroverlast en Hoogwater*. Den Haag: Overlegorgaan Fysieke Leefomgeving [document 4].
- Plate (2002) Flood risk and flood management. *Journal of Hydrology*, 267(1-2), 2-11.
- Pot, De Ridder and Dewulf (2024) Avoiding future surprises after acute shocks: long-term flood risk lessons catalysed by the 2021 summer flood in the Netherlands. *Environmental Sciences Europe*, 36(138), 16.
- Provincie Limburg (2021) *Omgevingsvisie Limburg*. Maastricht: Provincie Limburg [document 7a].
- Provincie Limburg (2021) *Provinciaal Waterprogramma 2022-2027; Cluster Natuur en Water*. Maastricht: Provincie Limburg [document 6].
- Provincie Limburg (2025) *Samenvatting Ontwerp Provinciale Omgevingsvisie Limburg (NL)*. Maastricht: Provincie Limburg [document 7b].
- Qin, Y. (2020). Urban Flooding Mitigation Techniques: A Systematic Review and Future Studies. *Water*, 12(12), 3579.
- Rijksoverheid (2021) *Kaart schadegebied*. Bijlage regeling Staatscourant.
- Rijkswaterstaat (2023) *Terugblik hoge waterstanden en storm Pia* [online] <https://www.rijkswaterstaat.nl/nieuws/archief/2023/12/storm-pia> (Consulted on January 5, 2025).
- Rijkswaterstaat (n.d.-a) *Ruimte voor de rivier* [online] <https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/ruimte-voor-de-rivieren> (Consulted on January 5, 2025).

- Rijkswaterstaat (n.d.-b) *Watersnoodramp 1953* [online] <https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/watersnoodramp-1953> (Consulted on January 13, 2025).
- RVO (2021) *Quick Scanrapport overstromings- en regenvalschade in Limburg en het onbedijkte deel langs de Maas in Noord-Brabant*. RVO.
- Saunders, M., Lewis, P., & Thornhill, A. (2016) *Research methods for business students*. Pearson.
- Schanze, J., Zeman, E. & Marsalek, J. (2006) *Flood risk management*. Dordrecht: Springer.
- Slob AFL, Rijnveld M, Chapman AS, Strosser P. (2007) Challenges of linking scientific knowledge to river basin management policy: AquaTerra as a case study. *Environmental Pollution*, 148(3), p. 867–874.
- Task Force Fact Finding Hoogwater (2021) *Hoogwater 2021 Feiten en Duiding*. Utrecht: Expertise Netwerk Waterveiligheid (ENW) [document 11].
- Tradowsky, J.S., Philip, S.Y., Kreienkamp, F., Kew, S.F., Lorenz, P., Arrighi, J., Bettmann, T., Caluwaerts, S. Chan, A.C., De Cruz, L., De Vries, H., Demuth, N., Ferrone, A., Fischer, E.M., Fowler, H.J., Goergen, K., Heinrich, D., Henrichs, Y., Kaspar, F., Lenderik, G., Nilson, E., Otto, F.E.L., Ragone, F., Seneviratne, S.I., Singh, R.K., Skalevag, A., Termonia, P., Thalheimer, L., Van Aalst, M., Van den Bergh, J., Van de Vyver, H., Vannitsem, S., Van Oldenborgh, G.J., Van Schaeybroeck, B., Vautard, R., Vonk, D. & Wanders, N. (2023). Attribution of the heavy rainfall events leading to severe flooding in Western Europe during July 2021. *Climatic Change*, 176(90), 38.
- UNU-EHS, UNU-CRIS & UNU-MERIT (2023) *Building Climate Resilience: Lessons from the 2021 Floods in Western Europe*. Montreal: United Nations University.
- Van den Hove S. (2007) A rationale for science–policy interfaces. *Futures*, 39(7), p. 807–826.
- Van Loon-Steensma, J.M. & Goldsworthy, C. (2022) The application of an environmental performance framework for climate adaptation innovations on two nature-based adaptations. *Ambio*, 51, p. 569–585.
- Van Tatenhove, J., Arts, B., & Leroy, P. (2000). *Political modernisation and the environment: The renewal of environmental policy arrangements*. Springer.
- Veiligheidsregio Limburg-Noord en veiligheidsregio Zuid-Limburg (2024) *Rampbestrijdingsplan Hoogwater Limburg 2023-2026*. Veiligheidsregio Limburg-Noord en veiligheidsregio Zuid-Limburg [document 15].
- Vitale, C. (2023) Understanding the shift toward a risk-based approach in flood risk management, a comparative case study of three Italian rivers. *Environmental Science & Policy*, 146, 13-23.
- Vogel C, Moser SC, Kasperson RE, Dabelko GD. (2007) Linking vulnerability, adaptation, and resilience science to practice: pathways, players, and partnerships. *Global Environmental Change*, 17(3–4), p. 275–302.
- Vrije Universiteit Amsterdam (2023) *Investeringsbestendig bouwen essentieel in risicogebieden* [online] <https://vu.nl/nl/nieuws/2023/investeringsbestendig-bouwen-essentieel-in-risicogebieden> (Consulted on January 5, 2025).
- Waterschap Limburg (2021) *Waterbeheerprogramma 2022-2027; Limburgs water in een veranderend klimaat*. Roermond: Waterschap Limburg. [document 16b].

Waterschap Peel en Maasvallei & Waterschap Roer en Overmaas (2015) *Waterbeheerplan 2016-2021; Water in beweging*. Venlo and Sittard: Waterschap Peel en Maasvallei and Waterschap Roer en Overmaas. [document 16a].

Waterveiligheid en Ruimte Limburg (WRL) (2023) *Opbouwplan Programma WRL; Gericht aan de slag!*. Waterveiligheid en Ruimte Limburg [document 5].

Weichselgartner J, Kaspersen R. (2010) Barriers in the science–policy–practice interface: toward a knowledge-action-system in global environmental change research. *Global Environmental Change*, 20(2), p. 266–277.

Wilby, R. L., Beven, K., & Reynard, N. (2007). Climate change and fluvial flood risk in the UK: more of the same? *Hydrological Processes*, 22(14), p. 2511–2523.

Wolf, S., Stark, N., Holste, I., Lehmkühl, F., Römer, W., Brughardt, L., Schüttrumpf, H. (2024) Evaluation of the high-energy flood of mid-July 2021 as a morphologic driver in the anthropogenically developed Ahr Valley, Germany, in interaction with infrastructures. *Environmental Sciences Europe*, 36(54), 15.

World Health Organization: WHO (2019) *Floods* [online] https://www.who.int/health-topics/floods#tab=tab_1 (Consulted on January 20, 2025).

Wreford, A., Moran, D., & Adger, W. (2010). Climate change and agriculture: Impacts, adaptation, and mitigation. *University of East Anglia: OECD*.

Wreford, A., Moran, D., & Adger, W. N. (2010). *Climate change and agriculture: Impacts, adaptation and mitigation*. Paris: OECD.

Zevenbergen, C., van Herk, S., Rijke, J., Kabat, P., Bloemen, P., Ashley, R., Speers, A., Gersonius, B., & Veerbeek, W. (2013). Taming global flood disasters: Lessons learned from Dutch experience. *Natural Hazards*, 65(1), 1217–1225.

Ziegler, C., & Muchira, J. (2023). Climate Change: The Ultimate Determinant of Health. *Primary care*, 50(4), 645–655.

Ziervogel G, Johnston P, Matthew M, Mukheibir P (2010) Using climate information for supporting climate change adaptation in water resource management in South Africa. *Climatic Change*, 103(3): 537–554.

Appendices

Appendix 1: Interview Guide

(in Dutch)

Introduction

Dank u wel voor uw deelname aan dit interview.

Dit onderzoek maakt deel uit van een masterscriptie over beleidsverandering in het Nederlandse waterbeheer na de overstromingen van 2021.

Ik wil u graag enkele vragen stellen over uw ervaringen en inzichten met betrekking tot wat er is gebeurd, hoe het is aangepakt, en wat er sindsdien mogelijk is veranderd.

Dan heb ik nog 2 vraagjes voor we beginnen, mag ik uw naam en functie gebruiken in mijn onderzoek of blijft u liever anoniem? EN Is het voor u goed als ik dit gesprek opneem en transcribeer?

1. Kunt u kort uw rol of betrokkenheid bij de overstromingen van juli 2021 beschrijven?

2. Hoe plotseling waren de overstromingen volgens u?

Waren er waarschuwingssignalen?

Was er veel tijd tussen het moment van signalering en de daadwerkelijke impact?

3. In hoeverre hebben de overstromingen schade toegebracht aan het milieu?

4. Hoe denkt u dat het evenement is waargenomen door de autoriteiten en belangrijke besluitvormers?

Zijn er nieuwe discussies of beleidsontwikkelingen ontstaan?

Hoe is het geframed? En waarom?

Policy change

5. Is er iets veranderd in het veld van actoren en belanghebbenden na de overstromingen?

Zijn er nieuwe coalities of drukgroepen ontstaan?

Factors of change

6. Zijn er twijfels ontstaan over de bestaande middelen voor overstromingsbescherming?

Is er nieuwe expertise ontwikkeld naar aanleiding van de overstromingen?

7. Denkt u dat de legitimiteit van het huidige overstromingsbeleid is afgenomen?

Zijn er nieuwe wetten of beleidsmaatregelen ontstaan?

8. Denkt u dat het vertrouwen in bestaande instituties en beleid is afgenomen als gevolg van de overstromingen?

Zijn er tegengeluiden of alternatieve verhalen ontstaan?

9. Welke veranderingen in wetten, beleid en strategieën heeft u waargenomen in het Nederlandse overstromingsrisicobeheer die gekoppeld kunnen worden aan dit specifieke evenement?

Factors of stability

10. Op welke manier beperken huidige bestuur dynamieken en verantwoordelijkheden de flexibiliteit en aanpassingsmogelijkheden na zo'n gebeurtenis?

11. Zijn er middelen beschikbaar om een nieuwe koers te varen, gezien de investeringen die al gedaan zijn in bestaande kennis en maatregelen?

Wordt er een nieuwe koers gevaren nu in het waterbeheer? Of meer inzetten op dingen die al gedaan werden?

12. Zijn de Nederlandse ruimtelijke ordeningswetten flexibel genoeg om waterbeheerbeleid en -strategieën te veranderen?

13. Zou een verandering in aanpak passen binnen de huidige narratieven en instituties van het Nederlandse overstromingsrisicobeheer?

Lessons

14. Welke lessen kunnen er volgens u worden getrokken uit dit overstromingsevenement en de reacties daarop?

Is het beleid volgens u voldoende veranderd om soortgelijke gebeurtenissen in de toekomst te voorkomen?

Wat zou uw advies zijn voor beleidsvorming?

Appendix 2: Atlas.ti Codebook (in Dutch)

Groups	Name
[Shock event]	<ul style="list-style-type: none"> ● ↗ ◆ Suddenness/unpredictability ● ◆ Presence/absence of warning signs ● ◆ Perceived unexpectedness by public or authorities ● ◆ Time between detection and impact
[Shock event]	<ul style="list-style-type: none"> ● ↗ ◆ (Possible) harm/magnitude ● ◆ Severity of disruptions to infrastructure or services ● ◆ Number of casualties ● ◆ Geographical scope ● ◆ Extent of financial damage
[Shock event]	<ul style="list-style-type: none"> ● ↗ ◆ Institutional responses ● ◆ Public or political framing of the event as exceptional ● ◆ Adoption of new policies or procedures ● ◆ Initiation of policy discussions
[Factors of change]	<ul style="list-style-type: none"> ● ↗ ◆ Resources and power (c) ● ◆ Doubts on increasing costs of flood infrastructure/maintenance or sudden financial cutbacks, opening alternative options ● ◆ New expertise (learning)
[Factors of change]	<ul style="list-style-type: none"> ● ↗ ◆ Rules of the game (c) ● ◆ Decreasing legitimacy of rules ● ◆ New rules
[Factors of change]	<ul style="list-style-type: none"> ● ↗ ◆ Actors and coalitions (c) ● ◆ Strong pressure by specific interests (actor coalitions) ● ◆ Entrepreneurs highlighting perception of sub-optimality of governance and approach
[Factors of change]	<ul style="list-style-type: none"> ● ↗ ◆ Policy discourses (c) ● ◆ New ideas, new problem definitions and policy concepts leading to counternarratives ● ◆ Diminishing trust in existing institutions and their efficiency
[Factors of stability]	<ul style="list-style-type: none"> ● ↗ ◆ Resources and power (s) ● ◆ Fixed costs and increasing returns through large investments in flood infrastructure (sunk costs) ● ◆ Learning effects: evolution of strong expert body of knowledge and strong epistemic community
[Factors of stability]	<ul style="list-style-type: none"> ● ↗ ◆ Actors and coalitions (s) ● ◆ Coordination effects: governance is sedimented in specific divisions of accepted responsibilities
[Factors of stability]	<ul style="list-style-type: none"> ● ↗ ◆ Rules of the game (s) ● ◆ Law has an important stabilising effect in the formalisation of rules and procedures
[Factors of stability]	<ul style="list-style-type: none"> ● ↗ ◆ Policy discourses (s) ● ◆ Adaptive expectations: public trust in existing institutions and their efficiency ● ◆ strong historical narratives