Room for rural interests in a large-scale water program

An Analysis for Corte-

TU Delft

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An Analysis for Cortenoever and Doesburg regarding Room for the River

by

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Credits of the front page picture: (Swart, 2020) **NOG AANPASSEN NAAR SNOWWHITE LUCHTFOTOGRAFIE!!!**

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Summary

1-page summary with advice for the problem owner; what advice do you give the problem owner and why? This advice should be understandable for a general audience unfamiliar with deep uncertainty methods and techniques.

Convincing advice in light of multi actor context, understandable for non-experts

Contents

1

Introduction

The North Sea flood of 1953, also known as the ”Watersnoodramp” in Dutch, was one of the most devastating natural disasters to hit the Netherlands in recent history. On the night of January 31st, a severe storm coupled with a high spring tide led to a surge in the North Sea, breaching the dikes at 90 points and causing widespread flooding in the southwest area of the country. Over 1,800 people lost their lives, tens of thousands were displaced, and vast stretches of fertile farmland were damaged by the saltwater, profoundly affecting the Dutch economy. In response to this catastrophe, the Netherlands embarked on an ambitious program of dike reinforcement and sea defense construction, known as the Delta Works, to prevent such a disaster from recurring. These engineering feats not only provided significant improvements in flood protection but also served as a model for other countries seeking to mitigate similar threats (Lamb, 1992, Wesselink, 2007)

However flooding can never be ruled out completely and the work on flood defense is never complete in a delta such as the Netherlands (Vergouwe and Sarink, 2016). Around 59% of the Dutch land surface is prone to flooding including 26% that lies below sea level. In terms of consequences, floods are among the worst disasters that can hit the Netherlands. (Knoop and Ligtvoet, 2014)

Besides the threat that is coming from the sea, the rivers in the Netherlands also pose a very real threat. If nothing is done the possibility could arise that the rivers in the Netherlands could flood and cause catastrophic damage (Bouwer and Vellinga, 2007). As a government, close collaboration with municipalities and water management companies is crucial to ensure the livability and safety of areas adjacent to rivers. In pursuit of this goal, a comprehensive flood protection strategy known as ”Room for the River” (RfR) has been developed. (Rijke et al., 2012, De Bruijn et al., 2015). RfR is one of the largest projects the Dutch have created in their fight against water. Its purpose is to generate more space for the IJssel river while creating an alternative for the heightening or construction of dikes.

However, these flood protection plans could also have some negative side effects. Due to the uncertain nature of resilience and a large number of actors involved, each with their own incentives to exploit these uncertainties, the problem has a win-lose character (De Bruijn et al., 2015). There is no one-size-fits-all approach to flood risk management.

As the RfR project operates within a complex multi-actor system that is characterized by deep uncertainty, government institutes have assigned analysts to study the risks and outcomes associated with a flood of the IJsel river. Our role as analysts is to explore potential solutions for the flood risk plan specifically focusing on Ring 1 & 2. These rings encompass the cities of Doesburg and Cortenoeve

In order to fulfill our role as analysts, this report aims to analyze uncertainties, levers, and policies, as well as the political context in which the problem is situated. Chapter 2 first frames the problem and formulates specific problem statements. Chapter 3 outlines the approach employed to address these problem statements. Subsequently, chapter 4 presents the results, which will be further discussed in Chapter 5. Finally, Chapter 6 concludes the report, and Chapter 7 gives an additional reflection on the political arena.

2

Problem Formulation

Considering the complexity of the Ijsel river case and the various ways it is perceived, it is crucial to frame the problem and formulate problem statements. To achieve this Section 2.1 provides an introduction to the case, followed by Section 2.2 which focuses on the actors involved and their roles and perceptions. Section 2.3 explores the influence of deep uncertainty on the risk strategy for solving the problem. Lastly, in Section 2.4, we articulate the formulated problem statements. These steps provide a foundation for the analysis of the IJsel River problem.

2.1. The IJssel River case

As the Netherlands is aware of the risks that water can bring to their land since the great flood of 1953, the assessment of flood risk is something that is not taken lightly (Klijn et al., 2011). One of the rivers in the land that poses a risk of flooding is the river ”the IJsel”. this river spans 127 km over the east side of the Netherlands and crosses a lot of densely packed areas where relatively large cities are. Some large cities along the banks of the river are Zutphen, Deventer, and Zwolle with a combined 283.000 inhabitants that would be seriously affected by a flood (Centraal Bureau voor de Statistiek, 2023). The IJsel River sprouts from the Rhine River in the east of the Netherlands near Arnhem as visualized in Figure 3.3. The Rhine is expected to increase its discharge of water by 20% by 2050 (ICPR, 2011). With this increase of water from the Rhine, the IJsel will also have an increased discharge of water. This water needs a place to go to, otherwise, the waterworks will not be able to cope, with a possible disastrous flood event as a consequence.

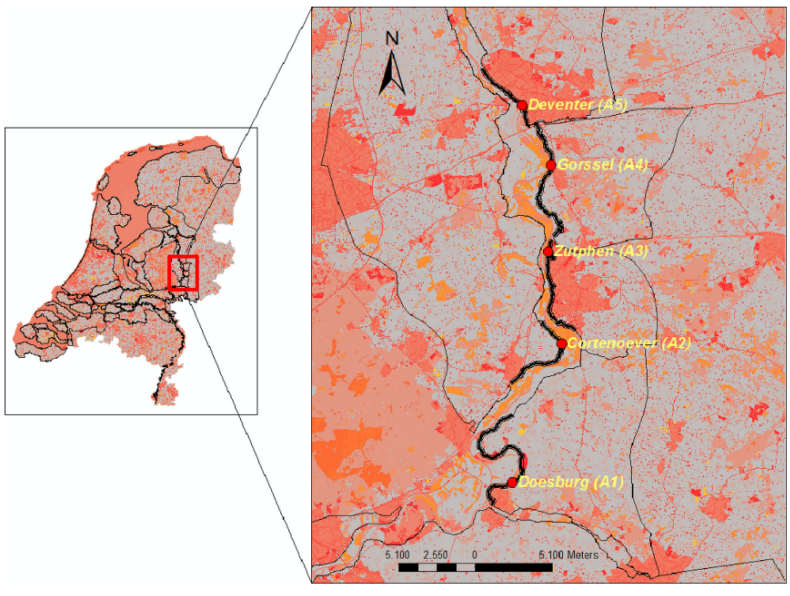

Figure 2.1: Location of the IJsel River and surrounding cities.

To increase the discharge of the rivers Rhine, Waal, Lek & IJsel without the probability of a flood also increasing, Rijkswaterstaat started the ”Room for the River” (RfR) program (De Bruijn et al., 2015). The primary objective of the Room for the River project was to create additional space for rivers to flow, thereby reducing the risk of flooding and protecting communities and valuable infrastructure.

For this program students are asked to develop a flood risk management plan for the upper branch of the river IJsel. The main goal of the flood risk management plan is to both prevent a flood event from happening and limit the damage when a flood happens. This program consists of different policies and measurements that can be implemented to enlarge the discharge capacity of the river. The measurements differ widely in costs and scope and that makes it a complex problem to solve. A simulation model is provided to assess economic damage and the number of casualties at several locations along the IJsel River.

The focus of this project lies on several areas of interest, called dike-rings (ring-shaped dikes that protect flood-prone areas). The locations of interest are Doesburg, Cortenoever, Zutphen, Gorssel, and Deventer. For this research, the dike-ring 1 & 2 are within the scope, and the locations that correspond to them are Doesburg & Cortenoever. About 12000 people live across the banks of this river in Dyke ring 1 & 2 combined (Allecijfers.nl, 2023). The aim of the project is to collaborate with all actors and simulate a real-life discussion between actors.

2.2. Actor analysis

De Bruijn (2015) emphasized in his paper the crucial need for an ”integral” or ”systems” perspective in river and flood management: policymakers and policy analysts should consider the entire river and its ecosystem as a whole. This systems perspective requires the involvement of all stakeholders, each with their own diverse and sometimes conflicting interests (De Bruijn et al., 2015).
Figure 2.2 visualizes a comprehensive overview of the actors involved and illustrates their interrelationships with each other and the policy to be made.

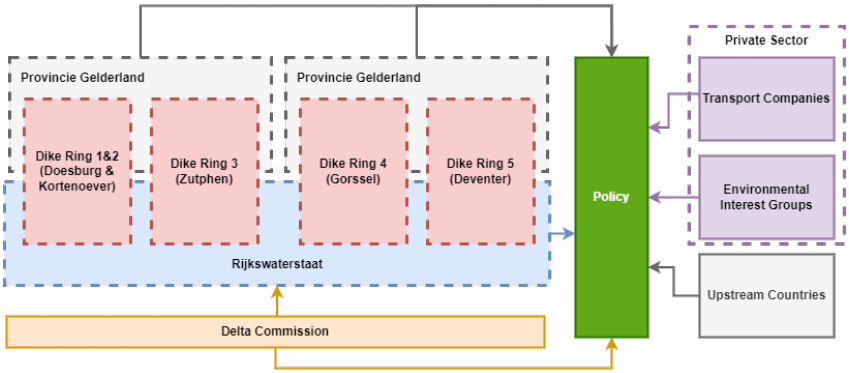

Figure 2.2: Actor overview

Within this political arena are critical actors who collectively determine the policies to be implemented Enserink et al., 2010). These actors include Rijkswaterstaat, Delta Commission, Gelderland Province, Overijssel Province, Transport Company, and Environmental Interest Group. Rijkswaterstaat, in particular, holds the most influential position, potentially affecting all stakeholders. Therefore, the project has high political sensitivity.

The political sensitivity of the RfR project becomes evident when considering the stakeholders and their perspectives. An overview of all the actors and their objectives, interests, and problem perception, as well as their power and interest level, is provided in Appendix A.

An intrinsically politically sensitive issue is resilience (De Bruijn et al., 2015). De Bruijn identified five key points that include the politics of resilience in relation to the RfR project. The following points are of high importance for the political analysis in the context of the RfR case:

- Fragmentation of the political structure. This arises from the involvement of numerous actors who lack complete representation of their interests and conflicting interests. For example, the dike rings have limited representation and rely on the Provinces to advocate for their concerns. Additionally, while most actors prioritise protecting citizens and farmlands, the Environmental interest group focuses solely on environmental concerns, while the Transportation group prioritises accessibility. The Environmental interest group supports the RfR project, which conflicts with the interests of farmlands in Dike Rings 1 & 2. However, implementing RfR may result in lower water levels that could hinder ship accessibility, potentially leading to environmentally harmful truck transportation as an alternative.

- Split incentive structure is a crucial point for especially Dike Ring 1 & 2 which are located upstream and the areas downstream that are affected by the actions taken upstream. If the RfR project is implemented in dike ring 1 & 2, the other areas downstream benefit from this. On the other hand, heightened dikes upstream will cause bigger water volumes downstream.

- Contested objective. Despite the presence of a provided model that includes underlying assumptions for the specific case, actors involved can still hold differing assumptions that lead to contested objectives. For instance, there may be disagreements regarding the potential environmental impact of the RfR implementation or the extent of farmland that the project will require. It is crucial to ensure the alignment of these assumptions among the actors involved to reach common agreements and facilitate decision-making.

- Contested impact. The project could face resistance from upstream regions, like Dike Ring 1 & 2 that don't want to bear the costs alone, as downstream regions also benefit from for example implementing RfR. This split incentive can lead to challenges to the anticipated positive impact on water safety and could cause delays in decision-making.

- Exceeding budgets and postponements. With the final responsibility for the flood risk management strategy, Rijkswaterstaat plays a crucial role in managing public funds efficiently to prevent budget overruns and project delays.

2.3. Deep uncertainty

Inherent to a systems approach are its many uncertainties (De Bruijn et al., 2015). Deep uncertainties, including natural uncertainties, have long been recognized as essential considerations in environmental decision-making (Kallis et al., 2009, Lempert et al., 2003). Increasing attention has been devoted to incorporating deep uncertainty in order to enable robust decision-making in flood risk management (Van Den Hurk et al., 2015, Haasnoot et al., 2013). Deep uncertainty refers to situations where decision-makers lack knowledge or agreement regarding the functioning of the system, the importance of various outcomes, and the future evolution of relevant external factors (Walker et al., 2013, Kwakkel et al., 2016). The IJssel River in the Netherlands provides an illustrative case study for exploring deep uncertainty in flood risk management.

Deep uncertainty, as defined by Lempert et al.(2003), refers to situations where analysts or decision-making parties face challenges in three aspects. Firstly, there may be uncertainty about the appropriate conceptual models that accurately describe the relationships among key driving forces. Secondly, there may be uncertainty in assigning probability distributions to represent uncertainty about key variables and parameters in these models. Lastly, there may be difficulty in determining how to evaluate and value the desirability of different outcomes (Lempert et al., 2003).

In the context of the Ijsel River case, these aspects of deep uncertainty are indeed encountered. Firstly, during the final debate, differing perspectives on the model led to disagreement among the actors. Rijkswaterstaat presented a policy that only included Room for the River measures in dike ring 1 and dike heightening in dike ring 3, based on their model's favorable outcomes. However, other actors argued that their own models yielded different outcomes, highlighting the uncertainty surrounding the appropriate conceptual model and its interpretation.

Secondly, Rijkswaterstaat emphasized the significance of uncertainty and its impact on decision-making during the debate. To address this, they proposed investing in an evacuation strategy to mitigate the risks associated with uncertainty, acknowledging that existing measures may not fully account for it.

Lastly, despite presenting a policy supported by their model's outcomes, Rijkswaterstaat faced opposition from other actors who had conflicting perspectives based on their own models. This divergence in interpretation and valuation of outcomes highlights the challenges in determining the desirability of different policy options, underscoring the difficulty in evaluating and valuing outcomes in the face of deep uncertainty.

To address the challenge of deep uncertainty, our report focuses on applying strategies for resilient flood risk management in the IJssel area. The objective is to develop a robust flood risk management plan that aligns with the political agenda of the involved stakeholders, ensuring effective risk reduction and consensus building (Van Herk et al., 2011). By employing methodologies that explicitly account for deep uncertainty, such as adaptive pathways planning and robust decision-making, thus shifting from 'predict and act' to 'explore and adapt', we aim to enhance the resilience of flood risk management in the IJssel region (Angela et al., 2010, Hall et al., 2012).

2.4. Problem Statement

dit moet dus nog aangepast worden:

"How can we accurately quantify and assess the magnitude of casualties and economic damages resulting from the deep uncertainty surrounding flood occurrences within 'Dike Ring 1 & 2'?"

and

"What is the extent of investment required to mitigate these risks, while also considering the potential casualties and economic damage in downstream areas affected by the floods?"

3

Approach

This chapter presents the modeling approach utilized for the ”Room for the River” project, employing the dike model provided by the course EPA1361. Prior to delving into this approach, it is crucial to comprehend the underlying model. In *Paragraph 3.1*, a concise overview and explanation of the ”Dike Model” are provided. Following the model explanation, the modeling process for decision-making under deep uncertainty is elucidated. *Paragraph 3.2* outlines the employed modeling methods and outlines the resulting process for gathering the depicted results in *Chapter 4*. *Paragraph 3.3* provides a brief overview of the model implementation.

3.1. Model explanation

In this section, we delve into the fundamental concepts and components of the Dike Model, shedding light on its policy levers, performance metrics, external factors and the relationships in the system (according to the XLRM framework seen in *Figure 3.1*). By familiarizing readers with the intricacies of this model, we lay the groundwork for a deeper comprehension of the subsequent modeling approach of *paragraph 3.2*.

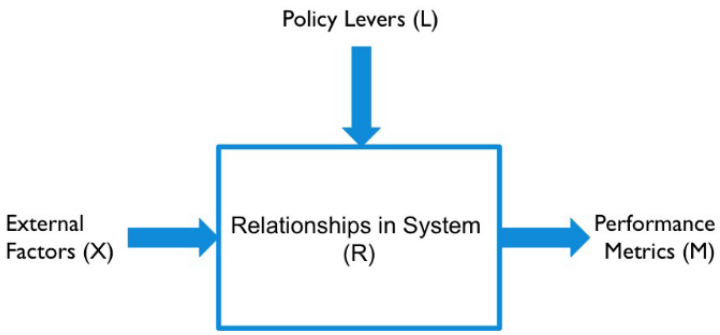

Figure 3.1: Conceptual XLRM approach in modeling Deep Uncertainty

As previously mentioned explanation of the model, possibly via the XLRM framework. Following this framework the model consists of the following elements:

- **External factors (X)**: External Factors in Deep Uncertainty modeling are also called uncertainties. The Dike Model includes the following uncertainties:
  - Discount Rate (Categorical)
  - Flood Wave Shape (Integer)
  - Breach Width (Real)
  - P_fail (Real): The chance that the dike will withstand the hydraulic load
  - Breach Growth (Categorical)

- **Policy levers (L)**: The levers entail all the policy options decision-makers have to influence the performance metrics of the model. The model includes the following levers:
  - Dike raising (Categorical)
  - Early Warning System (Integer)
  - Room for the River (Integer)
- **Performance Metrics (M)**: The Performance metrics of the model are the model outputs or outcomes. The model includes several performance metrics. For our analysis, we decided to combine some of the outcomes. The following performance metrics were used:
  - Expected Number of Deaths
  - Total Cost: This is a combination outcome between expected annual damages and dike investment costs.
  - Room for the River Total Cost
  - Expected Evacuation Costs

It is important to note that this model is split into 5 different dike ring areas. This is done to reflect the real-life reality of conflicting interests in policymaking. All of the different dike rings are represented by political institutions and are able to make autonomous decisions. In the model, this is reflected by the uncertainties, levers, and metrics being split between the dike rings.

3.2. Quality of the model output

We zouden hier nog helemaal los kunnen gaan op het paper van Dong (2019), gegeven bij AS, waarin je ingaat op de kwaliteit van numerieke data gegenereerd bij simulatiemodellen. Justifies de data die je vervolgens gebruikt voor analyse. Het is een kort paper.

3.3. Analysis Approach

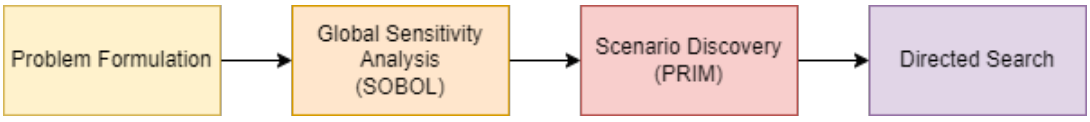

Figure 3.2: Analysis Approach of Dike Ring Model

<>

3.4. Open exploration

Uit AS: We want to find the relation between X = x1, x2, …, xn and Y = y1, y2, …, ym in an understanding or exploratory mode

3.4.1. Global Sensitivity Analysis

outline:

- Waarom sensitivity analysis
- Welke methode sensitvity analysis: Sobol (en waarom niet LHS??)(voordelen + nadelen/limitaties noemen)
- En waarom de andere methoden niet
- Welk experiment design (Sobol) + waarom + waarden (policies, experiments)

3.4.2. Scenario Discovery

outline:

- Waarom scenario discovery
- Welke methode sensitvity analysis: PRIM (voordelen + nadelen/limitaties noemen)
- En waarom de andere methoden niet
- Welk experiment design (LHS) + waarom + waarden (polcies, experiments)

uit AS: Sometimes we are interested in the relation X, Z -> Y: scenario analysis

3.5. Directed Search

outline

- Waarom directed search
- Waarom methode: multi-scenario MORDM (multi objective! Dus houdt ook rekening met de goals van andere actoren; al niet perse de verdelings effecten) (voordelen + nadelen/limitaties noemen)
- En waarom de andere methoden niet

3.5.1. Selection of scenarios

outline

- Hoe scenario's geselecteerd worden

3.5.2. Experiment design of multi-scenario MORDM

outline

- Welk experiment design (LHS) + waarom + waarden (geselecteerde polcies, X experiments)

3.5.3. Re-evaluation of policy options

- Waarom re-evaluation of policy options: robustness en best options for dike ring 1+2, maar rekening houdend met effecten voor anderen

Minimal maximum regret

- PRIM analyse: Zorgen geselecteerde policies niet voor problemen voor te veel kosten (RWS) of doden in D3+4+5?

PRIM analysis

- PRIM analyse: Zorgen geselecteerde policies niet voor problemen voor te veel kosten (RWS) of doden in D3+4+5?

3.6. Model Implementation

In the figure presented below, the implementation of the model analysis is presented. In purple, the files that contain the Dike Model and transforms the data from the Dike Model so that the outcomes are compatible for analysis with the EMA workbench. In blue, the steps are presented that perform either the experiments or optimizations, which generates the data for analysis. Specific analysis are conducted in steps indicated in orange.

As presented, the data used for open exploration is generated first (scenario discovery and global sensitivity analysis). The results generated with LHS are also used to select scenarios for Dike Model optimisation. With the resulting policies, new model runs are done for directed search. These model runs are then analysed.

Nog iets zeggen over aantal runs e.d.?? 1000 x 100, en hoe specifieke blokjes werken (PRIM e.d.), en hoe we uiteindelijk bij 6 selected scenario's komen en 24 selected policies? Of is dat iets meer voor bij de results?

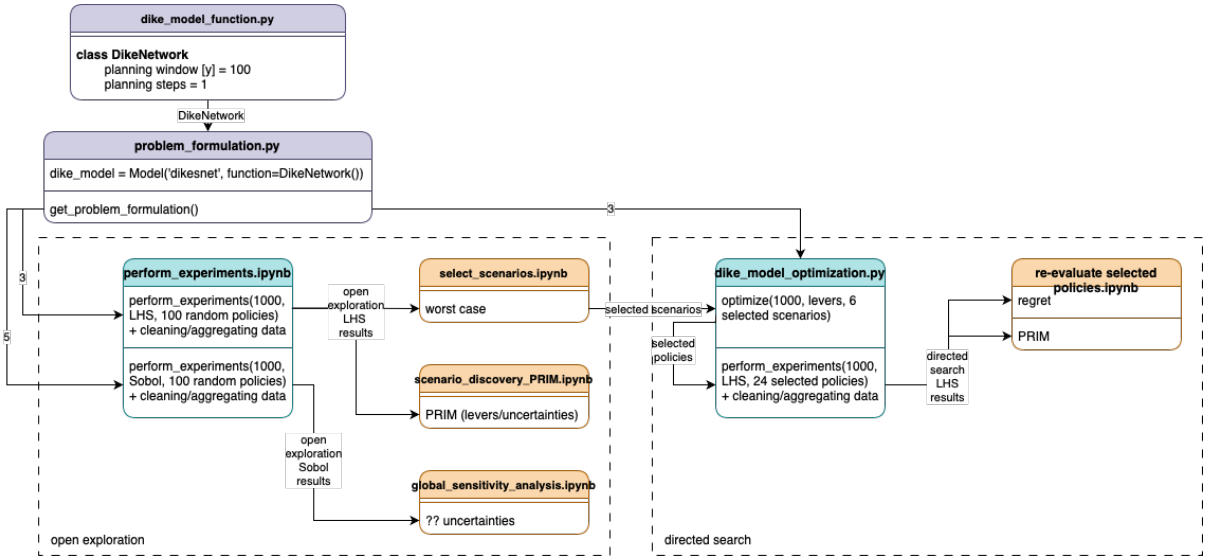

Figure 3.3: Implementation of analysis steps

3.6.1. aantekeningen

<> We willen achterhalen: ... Iets zeggen over de sampling method en number of runs Iets zeggen over wat specifiek de outcomes of interest zijn; en welke het meest van belang voor onze opdrachtgever

4

Results

In this chapter the results are presented from the analyses described in chapter 3. Firstly, the results of the open exploration are discussed for global sensitivity analysis for the uncertainties (4.1.1) as scenario discovery with PRIM for specific levers (4.1.2). Thereafter, the results of directed search are presented. The selection of the scenarios is presented in section 4.2.1, the outcomes of multi-scenario MORDM are given in 4.2.2 and the resulting policy options from this are re-evaluated in section 4.2.3 considering maximum regret and PRIM analysis.

4.1. Open exploration

As discussed in section 3.3, for the open exploration, 10.000 experiments have been run, based on 1000 scenarios and 10 policies with Sobol for Global Sensitivity Analysis and Latin Hypercube Sampling for Scenario Discovery. This results in the presented descriptives for the outcomes of interest in figure XXX.
CONCLUSIES

PLAATJE STATISTICS OUTCOMES - voor zowel Sobol als LHS!?! PLAATJE verdeling sampling?

As the municipalities within Dike Ring 1 and 2 are mostly interested in minimising risks regarding losing lives and economic loss, the outcomes are presented in the scatter plot in figure XX. As can be seen, the two outcomes are correlated, as both are a logical consequence when areas are flooded.

PLAATJE RELATIE TWEE OUTCOMES - kunnen we op dit level alleen uit Sobol halen aangezien LHS op PF3 zit?

To further analyse the uncertainties which result in such outcomes, scenario discovery is covered in section XX and global sensitivity analysis in section XX.

4.1.1. Global sensitivity analysis

With a global sensitivity analysis,

4.1.2. Scenario discovery with PRIM analysis

TEKST

4.2. Directed search

TEKST

4.2.1. Selection of scenarios

TEKST

4.2.2. Multi-scenario MORDM

TEKST

4.2.3. Re-evaluation of policy options

Minimal maximum regret
PRIM analysis
Houdt geen rekening met de verdelingseffecten tussen Dike Ring 3, 4 en 5. Misschien wordt 1 van de rings nog wel flink gehit. Tussen dike ring 1 en 2 maakt het niet uit, want je geeft het deel op waarbij de minste doden vallen, dus het meest landelijk gebied.

5

Discussion

Discussion; what are the key threats to the validity of your conclusions? What directions do you see for further refining or improving your analysis? Again, this should be grounded in literature and/or an awareness of the decision arena.

Identifies key limitations of their analysis from both a methodological point of view and the policy arena point of view. Discusses their implications for conclusions and suggests ideas for future work to overcome them

Aggregaties: door een level van problem formulations kiezen, zelf nog wat aggregaties. Een van de lectures had het hierover. Ook over het verschuiven van effecten tussen locaties of in tijd. Hier doen we dus weinig mee. Dike Ring 1 en 2 bij elkaar optellen?

Maar 1 seed gebruikt

Modeltechnische discussie vs. model gebruik discussie vs. politieke context (by design uitgelaten aspecten) en boeren en nitrogen samenvoegen want ook dit speelt mee in values

Is the model build without consideration of modellers bias? En presenteren/gebruiken we de model output genoeg i.c.m. limitaties (discussie) en onzekerheidsmarges (resultaten)> Kwakkel zei iets over dat er flaws by design zijn, en we hebben natuurlijk een beleidsmaker gediend, en het model is redelijk complex, dus iets meenemen als:

'as the model assumes things about X, and does not consider Y (andere indicatoren), it is important to note that the model could have given different outcomes when it had different parameters and outcomes. Therefore, it is a helpful tool but it should only be used to inform decision-makers, and not to justify (goede woord?) the decision. It is therefore also important to present the model output together with model limitations (underlying model uncertainty about accuracy/confidence of the model), also when it does not support an existing agenda. Thereby, the simulation model is rather complex. For the sake of increasing understandability, the model is somewhat simplified by considering 1 time step and a time horizon of 100 years (since people discount effects in the future - BRON), and gives therefore a rough and abstract idea about possible effects and the system- and location dependencies of choosing specific levers and policies.'

6

Conclusion

Conclusions; a more extended conclusion grounded in your results and discussion, leading to clear advice for your problem owner.

Convincing conclusions consistent with analysis advice is appropriate for problem owner and the multi-actor context

ARE WE A POLICY BROKER?? (slides week 6); solve stalemates and create new options for decision and policy making

7

Political Reflection

7.1. Information loss / Chinese whispers / Telephone game

The Chinese whisper game, also known as the telephone game, serves as a relevant analogy in the context of the project room for the River IJssel. Just like the game, where a message is whispered from one person to another, the project room involves multiple individuals and organisations collaborating and exchanging information about the River IJssel. However, as the information travels through this chain, there is a risk of it being distorted or misunderstood due to various factors such as differing perspectives, communication gaps, or subjective interpretations. Recognising this phenomenon, it becomes crucial for the participants in the project room to prioritise effective communication, active listening, and frequent feedback loops to prevent information loss and ensure that the intended messages and objectives are accurately conveyed and understood by all stakeholders.

7.1.1. Challenges & Tensions

One of the challenges that impacted the project as analyst was the information loss due to a challenge that can be explained with the analogy 'the Chinese whisper game'. When participating in the problem space there are a lot of different actors with many different opinions and believes, also there is a very wide-range of desired outcomes for all these different actors. As annalists of Dike-ring 1 & 2, we tried to gather as much information as possible next to giving as much information to our direct ally, Dike-ring 1 & 2. Although, one inherent problem that comes with a multi-actor problem is information loss (Dhir and Mital, 2012).

HIER MOET MEER TEKST

7.1.2. Mitigation

The thing with information loss is that it can happen by multiple different ways. People that have conversations with each other can interpret words in different ways which makes information loss a very realistic thing. Information loss can also be due to cognitive biases (Tversky and Kahneman, 1974), but another reason is because the text is just not tailored or "fit" for the listener (Sperber and Wilson, 1986). To make sure there was less information loss, we as annalists talked a lot with different stakeholders. This way we believed that our message would stick with the group of Dike-ring 1&2. Because we did some desk research on how to convey your message and especially from (Grill-Spector et al., 2006) we learned that repetitiveness has a positive effect on the memory in the case of discussions between multiple stakeholders. That made our strategy to have many conversations with the involved parties to repeat our story and make sure that the information loss was minimal.

7.1.3. Future mitigation

Moving forward the risk of information loss is still a problem during communications with other groups. Besides what is already implemented in the strategy, in the future the messages that will be conveyed will be tailored to the specific group of receivers. As the study of Sperber (1986) suggest, a tailored message is more effective in mitigating the effect of information loss. Next to that, for example, actors may intentionally withhold relevant information or provide vague or ambiguous statements, leading to

information gaps or misunderstandings (Grice, 1989). In the future this should be considered a risk and be met with appropriate strategy. One way of doing this is to stay polite but direct (Gallois and Ogay, 2005). The Dutch people are particularly good at doing this.

7.1.4. Risks of future mitigation

Implementing such strategy can bring some risk to the table. When tailoring the message to specific groups of people there is the change to oversimplifying the message or omitting important details, which may result in loss of nuance or accuracy. Next to that, tailoring the message could result in compromising the integrity of the information being conveyed. Finding the balance between clarity and completeness while maintaining accuracy is crucial to mitigate these risks and ensure effective communication. The risks of being polite and direct is that you can be perceived as too blunt or being misunderstood. Directness can result in being offensive and being polite could result in diluting the intended message.

7.2. The game of chicken

The game of chicken is a challenge where two people drive toward each other, and the first one to swerve is seen as ”chicken.” It represents situations where parties want the other party to take action, risking an unwanted outcome if neither does. The game sheds light on the decision-making process and appears to be a realistic description of strategic interactions within the context of game theory (Cabon-Dhersin and Etchart-Vincent, 2013).

7.2.1. Challenges & Tensions

Within the RfR case, the game of chicken theory illustrates one of the challenges we encountered. We faced the split incentive dilemma as analysts for dike ring 1 & 2, located upstream which led to a game of chicken. Implementing flood mitigation measures in our area would benefit downstream regions. Still, each actor hesitated to take costly actions, hoping that we as the actors for the areas upstream would act first. However, we would end up paying the costs, while the other actors would benefit. This collective inaction at first created a slight deadlock, delaying the formation of the overall flood risk management plan.

7.2.2. Mitigation

To address this challenge, we took inspiration from the research conducted by Cabon-Dhersin and Etchart-Vincent (2013) on framing and cooperative behavior in a Game of Chicken. Their findings highlighted the impact of using socially-oriented wording, such as ”I cooperate,” in increasing the level of cooperation compared to non-social labeling (Cabon-Dhersin and Etchart-Vincent, 2013). In line with these insights, we adopted a social approach to tackle this challenge. Instead of relying solely on brief and concrete email exchanges, we prioritized engaging in in-depth conversations with the other actors involved. By fostering meaningful dialogue, we aimed to build stronger relationships and enhance collaboration in order to overcome the hurdle of collective inaction effectively.

7.2.3. Future mitigation

To mitigate split incentives and promote collective action, our strategy is to establish a shared vision among all actors involved. We will encourage facilitating stakeholder engagement and collaborative sessions to ensure the voices of all relevant parties are heard. Through dialogue and active listening, we aim to identify common goals and values that form the basis of the shared vision. This vision will be documented, including a clear vision statement, and regularly communicated to foster a shared sense of purpose and commitment. By creating a common understanding, we can overcome split incentives, reduce resilience, and successfully create a timely flood risk management plan.

7.2.4. Risks of future mitigation

One risk associated with the strategy of establishing a shared vision is the potential difficulty in achieving consensus among actors with different interests. Conflicting opinions and competing agendas can lead to prolonged decision-making processes and obstruct progress towards the shared vision. Additionally, we could encounter resistance from stakeholders who may have reservations about the proposed

vision, which can lead to delays. Sustaining commitment to the shared vision over time also poses a challenge. To overcome these risks, proactive stakeholder engagement, continuous dialogue, and regular evaluation should be employed as effective risk management strategies.

7.3. David vs. Goliath

Another challenge that became evident during this project was that the role of analyst had the possibility to be overshadowed by the other groups. Next to that is the fact that Dike-ring 1&2 are the ones that will have to give in on their farmland to make room for the river. The Dike-ring 1&2 are the areas most upstream and thus the ones that will have everybody looking at them to do something that is beneficial for everybody downstream. During this whole project it is hard not to see a reference to David vs. Goliath.

7.3.1. Challenges and Tensions

During the project it was at multiple moments that we, as analyst, felt like David. The government and other decision making groups only wanted to have conversations with the analysts if they could have some sort of benefit from it. This is what was expected in some way but now it felt like we had to initiate a lot of the conversations. This caused some problems for us in making sure the other groups got all the information they wanted from us. Our morale became lower and we didn't have the motivation we had earlier on.

7.3.2. Mitigation

To mitigate the effect that David vs. Goliath has, we had several ideas when the challenge had arissen. One of the strategies was to forge stronger partnerships with other groups ans especially with Dike-ring 1&2. Study shows that forging partnerships will help to even out the power imbalance that could be in place in a situation (Bryson et al., 2006, Ansell and Gash, 2007, Emerson and Nabatchi, 2015).

7.3.3. Future mitigation

For the continuation of this project it is wise to think about extra measurements to not fall into the old ways again, meaning David vs. Goliath. The next step to mitigate the risk of become the same is to think about a strategic communication strategy. Articulating a compelling narrative that emphasises the project's value and the value of the analysts in that project could work.

7.3.4. Risks of future mitigation

The potential risks associated with the mitigation strategies of stronger partnerships include the challenge of achieving consensus among actors with different interests and agendas. Conflicting opinions and competing priorities may hinder the establishment of strong partnerships and impede effective collaboration (Laker, 2022). Additionally, resistance from stakeholders who may not fully embrace the shared vision can pose a risk to the success of the mitigation efforts. Sustaining commitment to the shared vision over time also requires ongoing effort and engagement.

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A

Political Arena

The case of the Ijsel river is situated within a complex network of multiple actors. In order to gain a comprehensive understanding of these actors and their roles in the multi-actor system, their power level and level of interest are outlined. Subsequently, their interests, objectives, and problem perceptions related to the case are described. Finally, a more detailed account is provided for each individual actor.

Table A.1: Power Interest Table

Actor	**Power**	**Interest**
Rijkswaterstaat	High	High
Delta Commission	High	High
Gelderland province	Medium-High	High
Overijssel province	Medium-High	High
Environmental interest group	Low-medium	Medium-high
Transport company	Low-medium	Medium-high
Dike rings	Low	High

A.1. Actors , ALLE REFERENCES MOETEN HIER NOG BIJ

A.1.1. Rijkswaterstaat

Rijkswaterstaat, as part of the Dutch Ministry of Infrastructure and Environment, assumes responsibility for the construction, design, maintenance, and overall management of critical infrastructure in the Netherlands (Rijke et al., 2012). Its primary objective is to ensure the safety, mobility, and high quality of life for all Dutch citizens (Ministerie van Infrastructuur en Waterstaat, 2021a). In the context of the Room for the River case, Rijkswaterstaat aligns its goals with these overarching objectives. Its role involves achieving the Room for the River (RfR) objectives while effectively engaging and maintaining the support of relevant stakeholders. Given the social, spatial, economic, and safety/security factors at play, policy decisions within the process require careful consideration of trade-offs. Rijkswaterstaat facilitates communication among stakeholders, enabling discussions on trade-offs and the implementation specifics of relevant policies.

A.1.2. Delta Commission

The Delta Commission, an independent advisory group, provides consultation to the Dutch cabinet on water security and the importance of flood risk management (Delta Commissie, 2008). While the commission officially concluded its duties and disbanded in 2008, it assumes the role of a decision-making authority with veto powers in the RfR case study. Their objective is to identify a sustainable, long-term solution that safeguards the interests of stakeholders.

A.1.3. Gelderland Province

The province of Gelderland, being the largest province in the Netherlands, holds responsibility for the well-being of Dike rings 1 through 4 within its jurisdiction. The provincial government (Provinciale Staten and Gedeputeerde Staten) oversees these areas. While scientific publications and news articles regarding Gelderland's stance on RfR are scarce, the province demonstrates transparency and openness by making the regional water planning program available for public inspection, review, and suggestions (Provincie Gelderland, 2021).

Additional insights on Gelderland's perspective on RfR can be gleaned from the EPA1361 political debate. The students representing the Gelderland province prioritize economic freedom, entrepreneurship, preventing farmland loss, and ensuring safety. Within the political arena, the provincial government possesses considerable power and instruments to reject strategies proposed by Rijkswaterstaat if they are not in the best interest of the province's municipalities and citizens. The students highlighted that this option would be seriously considered if their demands were not adequately addressed during the decision-making process.

A.1.4. Overijsel Province

The IJssel river serves as a natural boundary, separating Gelderland from the neighboring province of Overijssel. Similar to Gelderland, Overijssel holds authoritative power and represents the interests of multiple municipalities at the national level. However, in the context of RfR, the relevant municipality represented by the provincial government of Overijssel is Deventer. Unfortunately, scientific publications and news articles that express the province's position on RfR are scarce. Consequently, the viewpoints obtained from the EPA 1361 student debate will be utilized to shed light on the province, specifically Deventer's, stance towards RfR.

A.1.5. Environmental interest group

The environmental interest group is dedicated to the preservation of the natural environment and wildlife. The Room for the River project encompasses several aspects that align with the goals of environmental interest groups. The project's focus on "working with nature" and environmental restoration objectives, as outlined by STOWA (2021), generally garners a positive response from these groups. However, it is important to acknowledge that there are stakeholders who prioritize safety and security over environmental preservation, if the need arises. As a result, environmental interest groups may need to recognize and accept that trade-offs between safety and environmental concerns may be a realistic scenario in certain circumstances.

A.1.6. Transport company

The transportation sector heavily relies on the accessibility of the entire Netherlands, including the IJssel river (CBS, 2009). However, the interests of transport companies can sometimes conflict with those of other stakeholders, as their primary objective is the fast, reliable, and efficient flow of ships and goods throughout the Dutch river network. Safety and security of the region may not be explicitly prioritized by transport companies. The depth of the river plays a critical role in achieving their objectives. Therefore, any decrease in the depths of the IJssel or narrowing of the river could have serious consequences for the transportation sector.

A.1.7. Dike-Rings 1&2, Doesburg & Cortenoever

Doesburg and Cortenoever, both located upstream, share concerns regarding safety in their respective regions and are determined to prevent fatalities resulting from flooding in the next 60 years. Economic prosperity is also a significant priority for both municipalities. The debate highlighted their strong preference for dike strengthening and heightening measures rather than channel construction or Room for the River (RfR)-type implementations. Additionally, Doesburg aims to keep the costs for these measures below EUR 100 million over 60 years, while Cortenoever has a budgetary limit of EUR 180 million. However, the specific basis for these cost figures remains unclear.

A.1.8. Dike-ring 3, Zutphen

Zutphen is situated in a vulnerable position concerning potential flooding. While the debate did not provide in-depth details regarding Zutphen's position, it was evident that the municipality prioritizes safety

and security. They aim to achieve this without undergoing significant land reductions, aligning with the perspectives of Dike rings 1 and 2.

A.1.9. Dike-ring 4, Gorssel

Gorssel's economy is heavily reliant on agriculture, making land availability crucial for farming activities. As a result, the municipality holds a somewhat negative stance towards Room for the River (RfR) initiatives and instead favors dike heightening and strengthening measures. Similar to Dike rings 1, 2, and 3, Zutphen shares a strong concern for the safety and security of the region. On the other hand, Gorssel demonstrates a positive attitude towards Early Warning Systems (EWS), recognizing its value in enhancing flood preparedness and response.

Table A.2: Actor Interests, Objectives, and Problem Perceptions

Actor	Interest	Objective	Problem Perception
Rijkswaterstaat	Safety, mobility and a high quality of life for Dutch citizens	Propose a robust flood risk strategy that provides safety, accessibility, economic opportunities and protects the environment	Propose a robust flood risk strategy that serves the interests of Rijkswaterstaat, while taking into account the interests of the other stakeholders, and the time and budget
Delta Commission	Water security and suitable flood risk management	Consult the cabinet and Rijkswaterstaat on water security and flood risk strategies	Consult the cabinet and Rijkswaterstaat within the available time and budget
Gelderland province	Safety for citizens and farmlands, and thriving economic activities	Protect the safety of citizens and the farmlands from flood risks	Protect citizens and farmland from flood risks, while containing economic activities and the size of the farmlands
Overijssel province	Safety for citizens, and thriving economic activities	Protect the safety of citizens from flood risks	Protect citizens from flood risks, while containing economic activities
Environmental interest group	Blooming flora and fauna, biodiversity and a safe environment	Secure environmental protection and make other actors aware of the environmental risks regarding the RfR project	Ensuring environmental concerns are incorporated in the flood risk strategy
Transport company	Accessibility and optimal transport opportunities	Ensure transportation and accessibility via the Ijssel river	Ensuring the correct depth and width of the Ijssel river are incorporated in the flood risk strategy
Dike ring 1&2	Safety and room for citizens and farmlands	Protect the safety of citizens and farmlands from flood risks	Protect citizens and farmland from flood risks, while containing the size of the farmland
Dike ring 3 - Zutphen	Safety and room for citizens and stimulating economic development	Protect the safety of citizens from flood risks, and stimulate economic activities	Protect citizens from flood risks, while containing economic activities
Dike ring 4 - Gorssel	Safety and room for citizens and farmlands	Protect the safety of citizens and farmlands from flood risks	Protect citizens and farmland from flood risks, while containing economic activities and the size of the farmlands
Dike ring 5 - Deventer	Safety for citizens and the city	Protect the safety of citizens from flood risks, and protect the city	Protect citizens and the city from flood risks, while containing economic activities

B

Model specifications

C

Notes

Notes from final debate

Post on brightspace about how to inlever: Via bs en via 1 email met twee losse pfdjes met report en political reflection en een linkje naar github repository

Belangrijk: - goede code structuur (zie de regels) - replicatie moet makkelijk zijn! Kwakkel moet de notebooks kunnen downloaden en op run klikken en dezelfde resultaten krijgen

Debate Rijkswaterstaat: we have all failed in making all the posibile scenarios to analyse everythig, so will not make a descision fully based on model. daarnaast iedereen zal straks teleurgesteld weggaan, maar dat is een goed ding want iedereen moet iets inleveren voor the greater good.

policy proposal. rfr in dikering 1 en highten dike in dikering 3, also invest in evacuation to deal with uncertainty. this costs 130million. In future maybe more measurements, but this so far.

Delta commission: twee vragen: why no plan in dike ring 4? antwoord; policy daar heeft weinig effect en budget restrictions. vraag: in dike ring 5 quite uncertain that it is safe, wat zegt jullie analyse? antwoord: door rfr in 1 wel safe.

overijsel: no policy for our areas. does this cover our risks? antwoord yes. oke dan prima lol

Gelderland: we can indeed not just relay on model. thank you for sharing budget. cant we extend money for .. vraag, wat voor increase denken jullie aan vraag, wat voor rfr willen jullie precies? wees concreet. Met alleen dit kunnen we geen safety garanderen. Antwoord: ..

transport: waarom alleen rfr in 1? en hoe moeten wij daar varen? wij willen compensation wan twe willen blijven vragen? want geen boten meer anders. dus niet acceptable. en er is ook geen compensation mogelijk in dike 1

environmental: nature is hard to quantify so happy that we failed with the model. mooi dat rfr in dike 1 want natura 2000 en pesticides. dus agriculture weg is top. ook antwoord op transport: alleen maar zeggen unacceptable kan niet.

samenvatting: dus discussie gaat verder in op rfr in 1 en dikes in 5.

euhm nu is worse than basecase. dus model is blijkbaar anders lol.

dike highening in 5 blijk uit rijkswaterstaat model niet nodig, maar iedereen is er niet mee eens dus we doen wsss wel hier dikes maar nog even kijken naar kosten

volgende keer policy van te voren sturen. deze policy is short term

gelderland heeft joint policy proposal: max dike increase for 3a dn 5 5 to 6 increase in 1 and 2 and smaller increase in 4 rfr in location 0 in dikering 1 costs are 400 milion

delta wil dit niet want geld en wil alleen betalen voor rfr en duurt lang om te bouwen rijkswaterstaat: oke policy maar wie betaalt wat

transport wil alleen dieper rivier

als we nu dikes hoger doen, dan moeten we later wss alsnog rfr toepassen

details are missing in the model like deeping river etc. So we miss some important parts. -rijkswaterstaat

gelderland: kunnen we niet nu alleen besluiten over dike ring 3 en mensen beschermen en daarna niet gehaast de rest bekijken

rfr is payed by delta

rijskwaterstaat model geeft aan dat if rfr in 1 en dh in 3 dan as litle causal per year as when we highten every dike. critische vraag: ik wel scenario? lol

after progress with the last policy now back to the other?

—pauze–

now policy dike 1 - RfR in deep way and have small dh dike 2 - dike 3 - dikehg dike 4 - dike 5 - dighhg

hier eerst getallen aan plakken en establish long term vision. tegenargument: limited resources dus eerst hierover beslissing

tegenpolicy met presentatie dike 1 rfr

dus iets in de richting van rfr deep en dh samen in 1 dh in 2 dh in 3 4 rfr en dh 5 dh

kwakkel: van 6 jaar is deze het meest chaotisch setup van ruimte en vizualisatie maakt rijkswaterstaat het heel lastig voor zichzelf

technocratisch discussion zonder thinking carefully about the process bijv alleen maar korte spreek-tijd geven aan verschillende actoren. noting is to decide or everything. WAnt alles heeft effect op elkaar dus je kan niet per dike ring discusseren. Adaptive dingen want alleen maar temporaly oplossingen want je moet je kunnen aanpassen aan rigedness en uncertainty connect to other decision arenas. for example nigtrogen en farmers

massive ambiguity about model and outcomes. ook verschillende interpretatie van rfr, want alleen winter dike verplaatsen ipv zomer. Daarom is begrip van systeem heel belangrijk. sommige actoren caren over dingen die niet gedekt worden door het model. Dit is designed. lol groepje die model gedeelt heeft voor transparantie maar de achterliggende assumption niet dus werkt niet perse.