Protecting the Netherlands against the rising river

Flood risk protection management in and around the IJssel River Region

EPA1361: Model-Based Decision-Making
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Management Summary

Heavy rainfall is becoming increasingly common in the Netherlands and together with melting ice water, this leads to an increased risk of floods. Climate change is seen as one of the prominent causes. However, it is not so easily turned around in a short time. This creates a challenge on how to deal with the abundant water, especially around rivers. This research is conducted for the main executive decision-maker regarding water in the Netherlands: Rijkswaterstaat.

Hence, this research aims to find the best-fit solution for the abundant water in the IJssel river region while minimising the dissatisfaction with the solution amongst stakeholders and containing the costs of such a solution. To compass the aim of this research, the following research question will be answered: *“What policy strategy results in favourable outcomes, even if a worst-case scenario occurs, that will satisfy all actors and could thus be implemented in the current political situation?”* The research question will be answered with the use of the IJssel River model provided by J.H. Kwakkel.

Exploratory Modelling and Analysis (EMA) is used to answer the research question, specifically an open exploration and directed search for proposing policy strategies to Rijkswaterstaat. Open exploration is mainly used to find a worst-case scenario with no policy measures. A directed search is conducted to find the best-fitting policy options to minimise the expected deaths and investment costs.

This research indicates that doing nothing is no option, it will result in a high number of costs and expected deaths. Next, failure of dike 1 and dike 3 have the highest impact on evacuation cost, expected number of deaths, and expected annual damage. 42 policy options have been found. From the analysis, one can conclude that investing in RfR combined with dike heightening is not efficient and not necessary.

Rijkswaterstaat is advised to invest in dike heightening of the dikes 1 and 3 (7 and 8 cm) if chosen for dike heightening. Nevertheless, it is important for Rijkswaterstaat to keep in mind the different interests and goals of the other stakeholders and the fact this can be different from the results. Making concessions is inevitable in such a complex situation, with this amount of stakeholders. However, safety is not something the provinces and municipalities are able to compromise on. We advise that involvement of stakeholders is necessary. Therefore it is important for Rijkswaterstaat to persuade the stakeholders about the importance, effectiveness and efficiency of the proposed policy measures.

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1. Introduction

250,000 people were evacuated as a precaution in 1995 in the Netherlands, because of flood risk due to extreme weather (Rijkswaterstaat, n.d.). Luckily, this fiasco ended as a precaution as well. Heavy rainfall is becoming increasingly common in the Netherlands (KNMI, n.d.), and together with melting ice water, this leads to an increasing risk of floods (Rijkswaterstaat, n.d.). Climate change is seen as one of the prominent causes, but it is not so easily turned around in a short time. This creates a challenge on how to deal with the abundant water, especially around rivers.

One location that is prone to excess water is the IJssel river, which flows from Westervoort to the IJsselmeer. Along this river, various municipalities are located close to the water. Excess water could foreshadow floods which could potentially lead to death amongst citizens. Logically, this is something that should be prevented.

There are plenty of solutions to establish a continuous water flow through the IJssel. However, creating consensus amongst the stakeholders might be a challenge. This project's problem owner is Rijkswaterstaat, which has the goal to find a viable solution for the flood-risk problem, without having to dissatisfy stakeholders. The spatial boundary consists of the IJssel, particularly from Doesburg up until Deventer. There are various governmental stakeholders involved, namely Dike Rings Doesburg & Cortenoever, Dike Ring Zutphen, Dike Ring Gorssel, Dike Ring Deventer and two provinces, i.e. Gelderland and Overijssel. The last governmental actor is the Delta Commission. Additionally, there are non-governmental stakeholders involved as well: The Transport Company and The Environmental Interest Group. All of these actors are involved in the challenge of flooding and have ideas about a best-fit solution. The decision-making strategies in this research project are based on the IJssel River model.

This research aims to find the best-fit solution for the abundant water in the IJssel while minimising the dissatisfaction with the solution amongst stakeholders and containing the costs of such a solution. The best-fit solution is one where the expected number of deaths is minimised. The satisfaction of stakeholders can be measured through the costs per dike ring and qualitatively through the meetings with the stakeholders. The costs are defined through the following variables: Expected Annual Damage, Dike Investment Costs, and Room for the River (RfR) Investment Costs & Evacuation Costs.

Based on these outcomes, the following main research question is formulated: *What policy strategy results in favourable outcomes, even if a worst-case scenario occurs, that will satisfy all actors and could thus be implemented in the current political situation?* To answer this, several sub-questions have to be answered about different aspects of the main question.

(a) Which uncertainties influence the outcomes of interest the most?
(b) What would happen at worst to Rijkswaterstaat and the IJssel river area if no flood protection or mitigation measure would be implemented?
(c) What is the most favourable policy strategy in terms of expected deaths and costs?
(d) How undesired will the outcomes become, in case insufficient policies are implemented?
(e) What is the effect of the political context on the implementation of this report's advice?

Sub-questions (a), (b), (c) and (d) will be answered by executing analyses using the model and the EMA workbench. Sub-question (e), on the other hand, will be answered during the political reflection, based on amongst other things a debate between all involved actors.

This research uses a model to study the solution space for the abundant water in the IJssel river. The model is provided by the course with certain constraints as to the input variables and input values. This information can be found in chapter two. In this chapter, the approach and method are described in more detail. Chapter three points out the results that can help answer the research (sub)question(s). Knowing where different stakeholders are located in the actor playing field is important, thus chapter four discusses the political reflection. Conducting this research also leads to discussion points, which are described in chapter five. To finalise this research the conclusion is argued for in chapter six. The appendices show additional results.

2. Approach & Method

The problem of how Rijkswaterstaat can increase the flood security in the IJssel river area is a decision-making process with multiple uncertainties and changing conditions. Additionally, taking the interest of other stakeholders into account is important for Rijkswaterstaat. One can conclude that the described system is complex and deeply uncertain. According to Kwakkel & Pruyt (2013), human reasoning alone is incapable of analysing decision-making, hence one needs computer-assisted reasoning. Therefore, exploratory modelling and analysis (EMA) are conducted, specifically an open exploration and directed search. An overview is portrayed in Figure 1. To analyse and visualise outcomes of different policies under deep uncertainty the EMAworkbench in Python is used, which is developed by J.H. Kwakkel. By using EMA, the efficiency of different policy options can be assessed and candidate strategies can be iteratively improved (J. H. Kwakkel & Pruyt, 2013).

This chapter starts with a description of the model specification, on which the EMA analysis is based. Second, the open exploration is conducted to gain a broad understanding of how the IJssel model behaves under different scenarios. Lastly, the directed search will be conducted to find policy strategies using optimisation approaches.

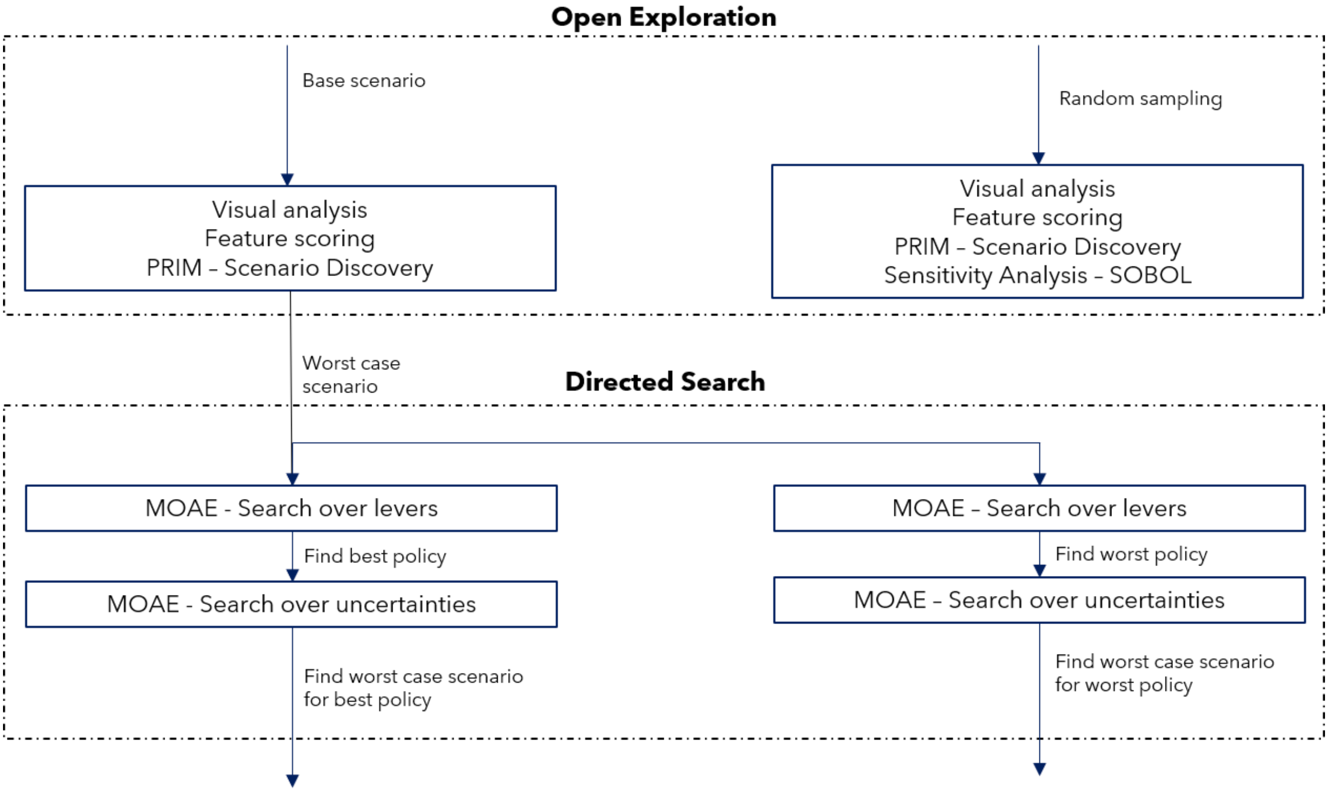

Figure 1: Overview of the used analyses

2.1 Model Specifications

For answering the research question the IJssel River Model is used. The IJssel River Model is based on the XLRM framework, which involves: Policy levers (L), which result in different strategies that can be used; External factors (X), considered to be uncertainties; Performance metrics (M), which are the computed outcomes, and; Relationships in the system (R), represented by the model itself, shown in Figure 2 (J. H. Kwakkel, 2017). The R parameter includes the set of rules and mathematical expressions linking the external factors to the policy levers, to compute the performance metrics. The XLM-parameters will be described in the following sections. Lastly, the time-step is accounted for in section 2.1.4.

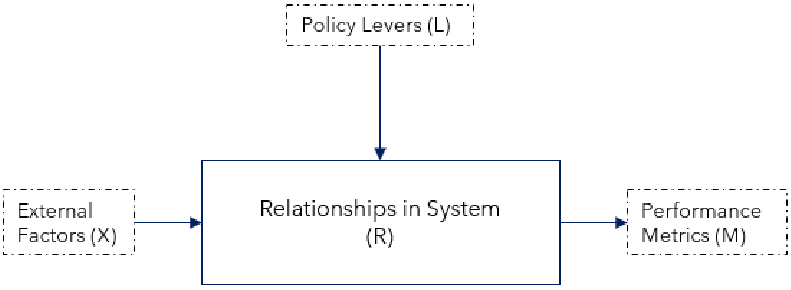

Figure 2: XLRM Framework (J. H. Kwakkel, 2017, p. 201))

2.1.1 Policy levers

Potential policies can be found through adjusting different policy levers in the model. These levers can be influenced by policymakers and they are all measures that can be taken to improve the outcomes for flood protection or flood mitigation. Flood protection measures include building or raising dikes, dunes, and dams or increasing the capacity of the riverbeds. Flood mitigation involves for instance early warning systems (EWS), the elevation of buildings or actions to raise awareness about floods (Silva et al., 2004).

Each lever is defined by a range of values, in which each value is a specific strategy for that part of the policy. All levers combined represent the lever space, with one point in the lever space being a policy. Each policy lever change comes with its costs and benefits. In this research, there are three policy levers taken into account with a certain value range, shown in Table 1.

Table 1: Policy levers

Policy Lever	Range	Unit
Dike Heightening [per dike ring]	0-10	[dm]
RfR projects [per dike ring]	0-1	[no implementation, implementation]
EWS [whole IJssel region]	0-4	[days]

Dike heightening and RfR projects can both be executed at each dike ring separately, while the EWS influences the whole IJssel region. Dike heightening, naturally, refers to the amount of dike raising, measured in dm. The RfR policy levers can either be set to 0 or 1, where 1 means that the project is implemented. At all 5 dike rings, it can be separately decided to implement the project or not. Each RfR project involves measures to prevent the water level from rising (de Bruijn et al., 2015). The EWS can limit damage and help avoid deaths. If the EWS is set to 0, no early warning is provided. If chosen to implement the EWS, a value of 1 to 3 days can be used. The higher this value, i.e. the earlier the warning is provided, the more effective the response will be. On the other hand, when the warning is provided earlier, there is a higher chance that the event will not happen; the chance of a false alert increases.

2.1.2 Uncertainties

The model contains different parameters, including uncertainties. Uncertainties are factors that policy-makers are unable to control. They cannot deliberately be reduced and cannot be known before making a policy. Neither the exact consequences nor the probabilities of the uncertainties are known. Each uncertainty is defined by a range of values, shown in Table 2, where each value stands for one particular situation. All uncertainties combined represent the uncertainty space. A point in this uncertainty space is one scenario.

Table 2: Uncertainties

Uncertainty	Range	Unit
Flood wave shape	0-140	[-]
Dike failure probability [per dike ring]	0-1	[-]
Final breach width [per dike ring]	30-350	[m]
Breach width model [per dike ring]	(1, 1.5, 10) for 5, 3, 1 day respectively	[day^{-1}]
Discount rate	(1.5, 2.5, 3.5, 4.5)	[-]

There are 140 different flood wave shapes, which each includes a normalised curve that describes the discharges at the most upstream location, over time. The dike failure probability and the final breach width are both self-explanatory. The breach width model describes the breach development over time by definition of a growth rate. Three growth rates are defined, 1, 1.5, and 10, which result in the final breach width being reached within 5, 3, or 1 days. The discount rate describes the value in the present, based on the expected damage in the future. A lower discount rate means that currently, the damage to future generations will be valued more.

2.1.3 Outcomes

A combination between a scenario and a policy is an experiment, which gives one set of outcomes, shown in Table 3. Each experiment results in several outcomes, depending on which problem formulation is chosen. The problem formulation for Rijkswaterstaat should include outcomes for each dike ring, and the Key Performance Indicators (KPI) are thus:

Table 3: Outcomes of interest

KPI	Unit
Expected Annual Damage [per dike ring]	€
Expected Number of Deaths [per dike ring]	[-]
Dike Investment Costs [per dike ring]	€
RfR Investment Costs [whole Ijssel region]	€
Evacuation Costs [whole Ijssel region]	€

The expected annual damage and the number of deaths are self-explanatory. The investment costs are determined by the costs required to raise the dikes. The evacuation costs are defined as a function of the number of people evacuated and the number of days they need to be evacuated from their homes. The RfR costs depend on the number of implementations and the types of the implemented RfR projects. The first three outcomes are aggregated to obtain the outcome for all dike rings together. Each of the outcomes should be minimised as much as possible, as they are all negative outcomes. Based on the outcomes, several analyses can be executed (Saltelli et al., 2008).

Based on the KPIs, one needs to select outcomes of interest for Rijkswaterstaat. This research aims to find the best-fit solution for the abundant water in the IJssel while minimising the dissatisfaction with the solution amongst stakeholders and containing the costs of such a solution. Therefore, all the above described KPIs are of interest for Rijkswaterstaat. As a consequence, problem formulation 3 will be used to calculate the outcomes of all different KPIs per municipality. Therefore, Rijkswaterstaat can obtain information on how uncertainties and policy levers influence each dike ring. This problem formulation will be used to explore the model uncertainties and policy levers. Second, problem formulation 2 will be used to calculate aggregated outcomes for all municipalities. Therefore, Rijkswaterstaat can obtain information on how uncertainties and policy levers influence the overall aggregate outcomes of interest. This problem formulation will be used to find the best-fit solution space.

2.1.4 Timestep

All analyses are executed over a time horizon of 200 years. To incorporate adaptive planning in the model, three planning steps are used. Each time step involves 200 divided by 3 (66.7 years each step). Decisions can be adjusted during these planning steps and therefore policies can be implemented at later points in time. This adaptive planning method ensures flexibility in policy-making, which is especially useful for making decisions under deep uncertainty. Decisions made solely based on a future predicted at one moment are not robust to deviations, causing the performance of this decision-making to deteriorate quickly (J. H. Kwakkel et al., 2015). In deep uncertainty, there will likely be deviations from made predictions and thus this is not a suitable method for making decisions. Adaptive planning improves this, by introducing the possibility of adapting certain policy decisions after a certain time (Hamarat et al., 2013).

2.2 Open exploration

Open exploration is used to gain a broad understanding of how the IJssel model behaves under different (futural) assumptions (Cariboni et al., 2007). It relies on the systematic sampling of the uncertainty or the decision space of the model. The used analyses for open exploration in this research are scenario discovery and sensitivity analysis. Both scenario discovery and sensitivity analysis are respectively explained in the next two sections. Open exploration is executed both for a base scenario and for random sampling to get a wholesome view of the project. In the base policy, all policy levers are set at zero. This is what happens if no solution is implemented. Based on the base policy, the worst-case scenario is derived. During random sampling, various random policies are utilised in the model. Therefore, one can foresee the model's behaviour under different uncertainties and levers.

2.2.1 Scenario discovery

The IJssel river model contains various uncertainties, as discussed in the previous chapter. This leads to different plausible future states. Scenario discovery assists policy-makers and analysts in identifying policy-relevant scenarios (Bryant & Lempert, 2010). For this study, the worst-case scenario for the base policy is relevant, the goal is to explore the model's behaviour during a worst-case scenario. To find this worst-case scenario, a scenario discovery technique called Patient Rule Induction Algorithm (PRIM) is used. The identified scenario with the use of PRIM can be used for the designing of adaptive policies (Hamarat et al., 2013). PRIM is chosen since it is highly interactive, presents multiple options for the choice of scenarios, and it uses visualisations that help to balance amongst the three measures of scenario quality: density, coverage, and interpretability (Bryant & Lempert, 2010). PRIM starts with a candidate box that covers the entire uncertainty space and it will make this box smaller by peeling parts of the uncertainty space step by step while maximising predefined outcome points using the PRIM algorithm (J. Kwakkel, 2021a). For scenario discovery, 10.000 scenarios will be analysed due to limited available computational power.

2.2.2 Sensitivity analysis

To understand what impact the model uncertainties have on model outcomes and behaviour two types of sensitivity analyses are performed. Sensitivity analysis is to find how uncertainty the output of a model can be apportioned to different sources of uncertainty in the model input (Saltelli et al., 2008). With the use of sensitivity analysis, the impact of the external factors on specifically Rijkswaterstaat KPIs are tested. A global sensitivity analysis (GSA) will be conducted with the use of Sobol indices (J. Kwakkel, 2021b; Sobol, 2001). GSA is where uncertain inputs are sampled at the same time, to understand how uncertainty in output is a function of uncertainty in model input (Sobol, 2001). Sobol is based on variance decomposition, as it tries to explain how variance in the model output is added by the variance in each uncertainty. It is an accurate and user-friendly method, but rather computationally expensive. Three indices can be computed, the first-order effect (S1), the total effect (ST), and the second-order effects (S2). For this research, only S1 and ST will be used. S1 represents the direct influence of the uncertainty on an outcome of interest, i.e. how much does this single uncertainty on its own add to the variance of the outcome. ST, on the other hand, describes how much an uncertainty influences an outcome when including all interactions of this uncertainty. This includes both the direct influence and the indirect influence on other uncertainties. Both S1 and ST are determined for all uncertainties, for two outcomes: the total number of deaths and the total costs. For the sensitivity analysis, 250 scenarios and 50 policies will be analysed due to limited computational power.

2.3 Directed search

Directed search is a search technique that uses optimisation to find policies and scenarios within the solution space of a model (Maier et al., 2019). Directed search is typically used for finding worst-case scenarios, policy design and for finding tipping points, or boundaries, of policy switches (Maier et al., 2019). Multi-objective evolutionary algorithms (MOEA's) will be used as algorithms for model optimisation. A MOEA's found policy set is defined using the concept of Pareto optimality; a solution is Pareto-optimal if no other feasible solution exhibits improvement in an objective without sacrificing performance (Watson & Kasprzyk, 2017). In this research, MOEA will be used to find fitting policies by searching over levers. Furthermore, to analyse the found policies, a search over uncertainties will be executed.

For both the search over levers and uncertainties 10000 number of function evaluations (nfe), based on the lack of computational power and the iterative process of checking the outcomes with the nfe. Also, for both methods, an epsilon value of 0.01 is chosen because this is small enough to precisely define the solution space.

2.3.1 Search over levers

Search over levers is a method that is used to find policy lever values that maximise desirable outcomes. Consequently, a sub-set of policies is found that can be used for further analyses. The Arrow's paradox states that ordinal preferences for single actors can not be translated to a community-wide preference (Kasprzyk et al., 2016). Because of Arrow's paradox, the desirable policies will be analysed per scenario and not for every scenario altogether. Furthermore, a many-objective optimisation will be executed for each of the selected scenarios because many-objective planning can aid in battling Arrow's paradox (Kasprzyk et al., 2016). The scenario that will be used is the worst-case scenario that is found analysing the effects of the base policy. The found policy space contains policies that are most effective for a worst-case scenario if no action is taken.

2.3.2 Search over uncertainties

Out of the policy space found by searching over the levers the found best policy and worst policy are selected. A MOEA by searching over the uncertainties of the selected policy is used. As a result, the worst-case scenario of the worst policy and best policy can be found. This will aid the Rijkswaterstaat in knowing the possible worst consequences of both policies.

3. Results

This chapter aims to find the answers one needs to discuss the research questions. First, the results of the open exploration are explained, after which the results of the directed search are pointed out.

3.1 Open exploration

The open exploration includes sampling over the uncertainties for a base scenario, and random sampling over different policies.

Problem formulation 3 with all 5 outcomes of interest per dike ring is used for open exploration, as explained in section 2.1.3. The 5 outcomes of interest can give Rijkswaterstaat a good overview of how the different uncertainties and policy levers interact with the different outcomes of interest.

3.1.1 Base policy

In the base policy, all policy levers are set at zero. The strategy would be to do nothing. For this policy, a visual analysis, feature scoring, and scenario discovery using PRIM are executed.

A pairplot between the outcomes is visible in Appendix A1. From this pairplot can be derived how outcomes correlate with each other. For each dike ring, it appears that there is a correlation between total costs and expected number of deaths when no policy is taken. This makes sense, as in the case of a flood, both damage and the expected number of deaths will increase. No clear correlation is visible between outcomes for different dike rings. This suggests that a flood in one dike ring does not necessarily result in floods for other dike rings. RfR total cost and expected evacuation costs are all zero, as no policy measures are taken in this base scenario.

In Appendix A2, the results of the feature scoring are visible. This provides an insight into how the model reacts to changes in the uncertainties. As expected, there is a clear impact of dike failing on the outcomes in that specific dike ring. This effect is the highest for dike ring 1. Failure of one dike ring appears to slightly affect damage and deaths in other dike rings as well. Mainly a failure in dike ring 1 affects the outcomes in other dike rings.

A PRIM scenario discovery is conducted to identify the combinations of levers and uncertainties that result in the worst-case scenarios for Rijkswaterstaat. The expected number of deaths are aggregated over each dike ring, to obtain a general idea of all deaths. The PRIM analysis is executed for the top 90 percentile worst-cases for all deaths, as this is seen as the most important KPI. The plot shown in figure 3 shows that for the reference policy the chance of failure for dike rings 3 and 1 is higher in the worst-case scenario compared to the chance for dike rings 2 and 4. Furthermore, one can conclude that the box with the worst-case scenario is concentrated in the region of 0 and 0.2 of pfail for dike ring 3 and in the region of 0 and 0.6 of pfail for dike ring 1. The lower the pfail value the higher chance of dike failure.

The worst-case scenario obtained from this part of the scenario discovery will be used in the directed search.

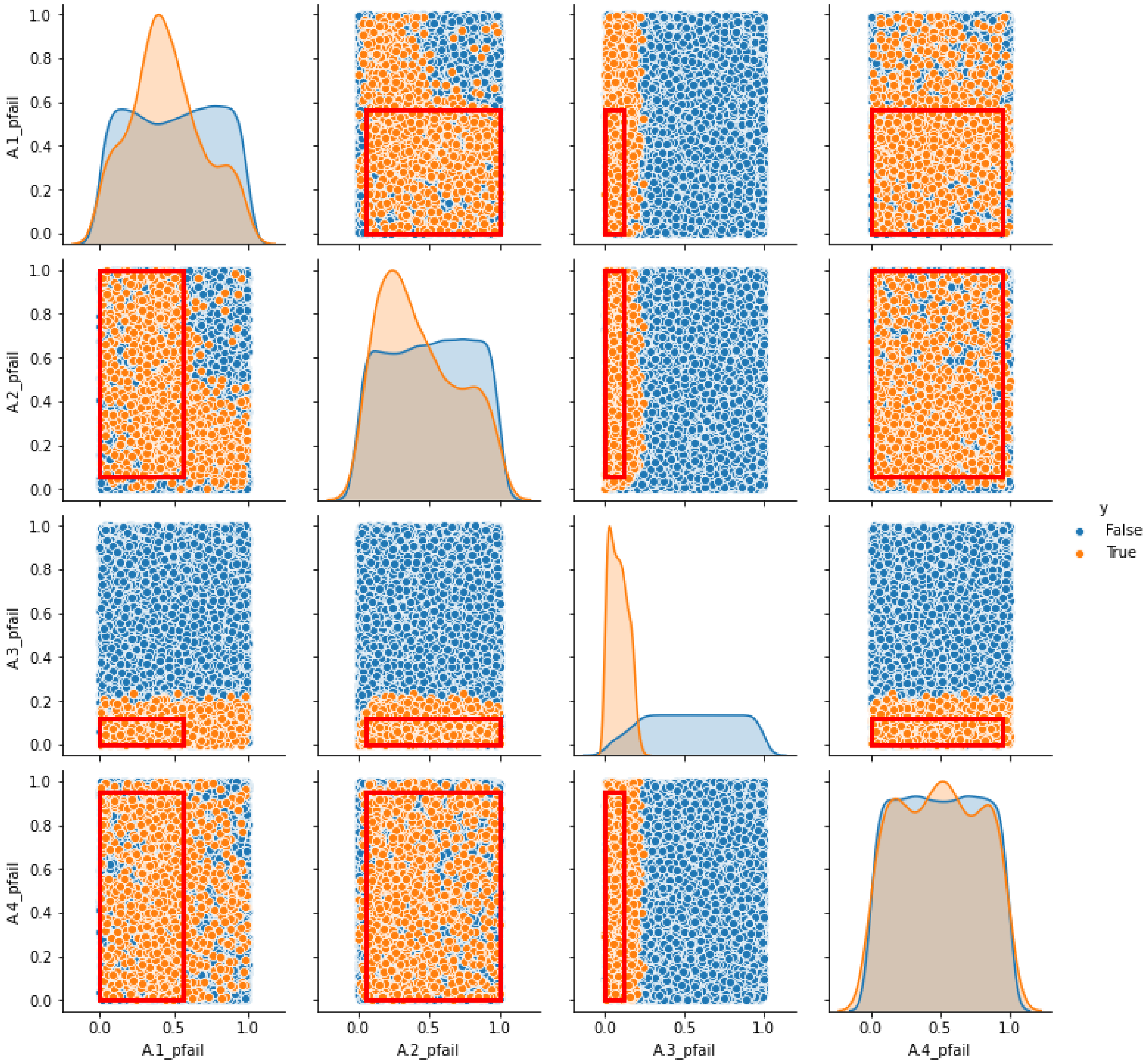

Figure 3: PRIM analysis scatter plot

3.1.2 Random sampling

The same analysis is performed, but now using random sampling. Instead of only considering the influence of different uncertainties, the impact of different policies can now be analysed.

In appendix A4, a pairplot for all five outcomes aggregated over the locations is visible. Notably, no correlation shows between both dike investment costs or RfR costs with expected annual damage or expected number of deaths.

The results of the feature scoring can be found in appendix A5. The highest influence is found for the failure of the dikes in dike ring 3, on evacuation cost, expected number of deaths, and expected annual damage. This suggests that failure in this dike ring has the highest impact on the outcomes and that this should be prevented at all costs.

Results from the random sampling are also used to perform a GSA with Sobol. For this goal, the deaths and costs are aggregated to a total number by summing them over all locations. The values found for S1 and ST are visualised in Figure 4 and 5 respectively. Influences below a threshold value of 0.01 are removed from the graph to enhance visualisation. The uncertainties that mainly influence deaths are again the failure of dike rings. In this case, the four most important dike rings appear to be dike rings 1, 2, 3, and 5. It is interesting to note that when taking costs as an outcome, only dike ring 1 and 3 have a lot of influence. For this outcome, the discount rate also starts to have some influence, but only when incorporating the interactions of this uncertainty with other uncertainties, i.e. in the ST.

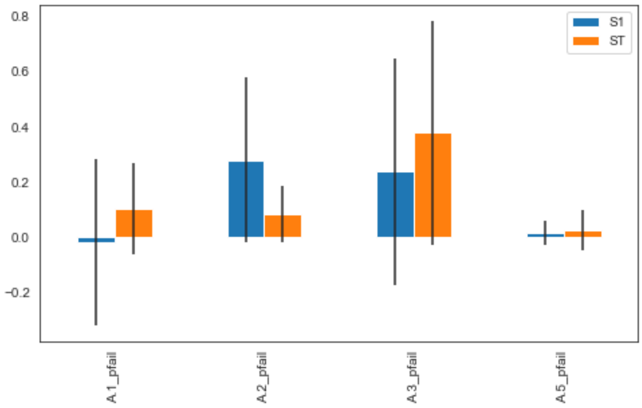

Figure 4: SOBOL Analysis, with total number of deaths as outcome

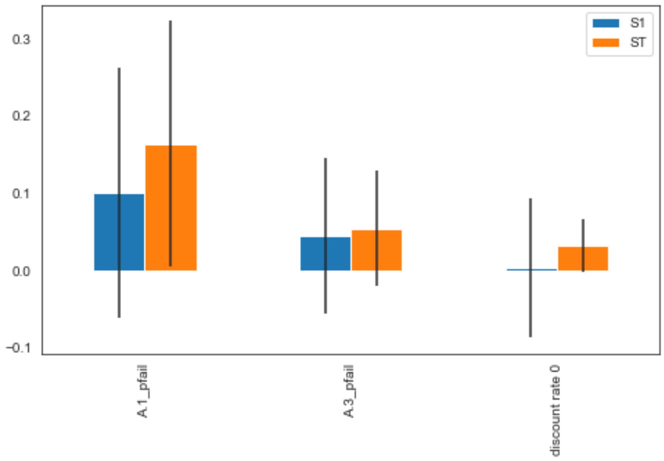

Figure 5: SOBOL Analysis, with total costs as outcome

3.2 Directed Search

In this section, the results extracted from the directed search are discussed. Based on the base scenario with all policy levers set at 0, a worst-case scenario is extracted in which the outcomes are at their worst. The inputs of this scenario are used in the directed search.

Problem formulation 2 with the outcomes aggregated over the municipalities is used for directed search, as explained in section 2.1.3. The outcomes of interest can give Rijkswaterstaat a good overview of how the policy levers interact with the different outcomes of interest.

3.2.1 Optimisation over the levers

Optimisation over the levers was executed to find the policy that results in the best outcomes, even for this worst-case scenario. Several outcomes were used as objectives to optimise over. First, the optimisation was done to minimise the expected number of deaths and the total costs, in all dike rings over the whole time horizon (all planning steps). For these settings and objectives, 42 solutions were found. The epsilon convergence plot is visible in Appendix A4.

In Figure 6, three important outcomes are shown. Because the expected number of deaths strongly correlates with expected annual damage, it was chosen to only visualise the deaths to enhance clarity. Dike investment costs and RfR investment costs are two important sources of the total costs and are thus chosen to be visualised. As visible, low costs for either two investments result in a high number of deaths. This suggests that costs have to be made either way, whether it be in investment for dikes or RfR. During the optimisation, no solutions are found in which both RfR and dike costs are at a maximum. This implies that it is not useful to invest in both projects at the same time to reduce the number of deaths; investment in only one suffices to reduce the number of deaths.

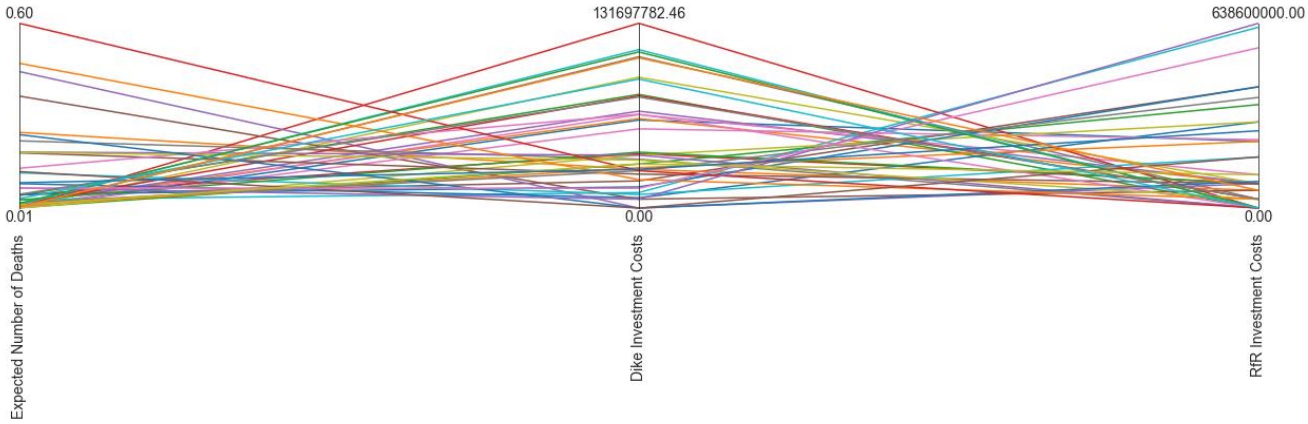

Figure 6: Parallel plot for the best policy for three outcomes: expected number of deaths, dike investment costs, and RfR investment costs

In addition, this optimisation was executed to find the worst possible strategy. This resulted in 98 solutions. This mainly showed that even with very large investment costs, still, a high number of deaths can occur. This stresses the importance of careful policymaking.

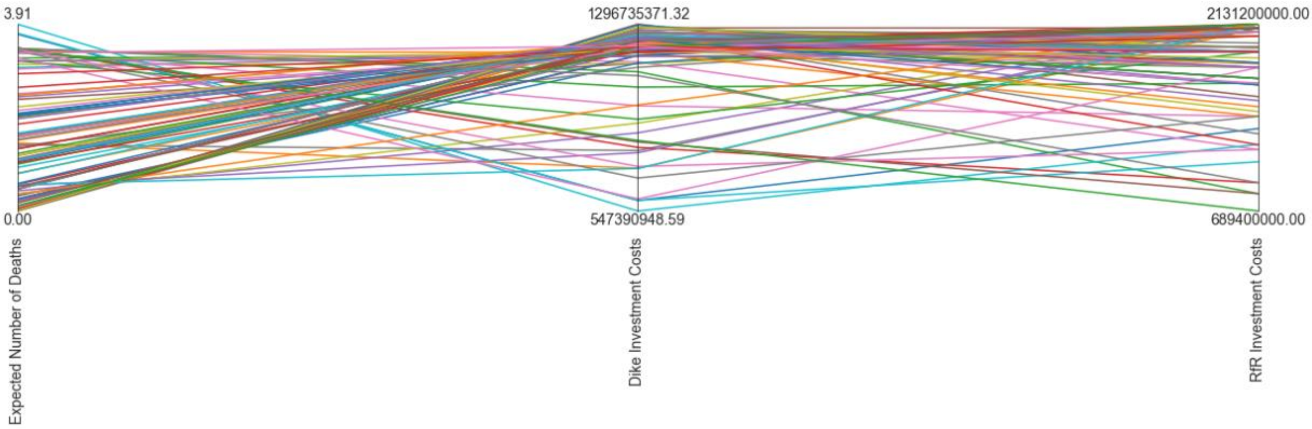

Figure 7: Parallel plot for the worst policy for three outcomes: expected number of deaths, dike investment costs, and RfR investment costs

3.2.2 Optimisation over the uncertainties

Consecutively, a random policy with the best results is extracted from these 42 found solutions, this policy can be found in appendix A5. For this policy, the worst-case scenario is found by optimising over the uncertainties. The epsilon convergence plot for this optimisation problem is found in Appendix A4. Even for this worst-case scenario, the expected number of deaths remains almost zero (Table 4). However, to reach this, very large investments have to be made. This emphasises the importance of the trade-off that has to be made by Rijkswaterstaat between total costs and the expected number of deaths.

Lastly, using the results of the optimisation over the levers, a random worst policy was extracted as well. Then, optimisation over the uncertainties is executed for this worst policy, to find the worst-case scenario for the worst policy. The epsilon convergence plot for this optimisation problem is found in appendix A5. This result shows how disastrous the outcomes could be when a bad policy is chosen. As visible in Table 4, the expected number of deaths is unacceptably high, while the investment costs for both dikes and RfR are much higher than for the best policy as well. The exact values of the policy levers are visualised in Appendix A6.

Table 4: Outcomes for the worst-case scenario for both the best and the worst policy possible

Outcome	Best policy	Worst policy
Expected Number of Deaths [-]	0	3.52
Dike Investment Costs [10^6 €]	63.768	547.39
RfR Investment Costs [10^6 €]	84.600	1203.9

4. Political Reflection

Ideally, the given advice will perfectly blend into the real-world decision-making process. However, due to the large variety of interests of the multiple stakeholders, it might not be desirable to completely follow the given advice. This section of the report contains a thorough reflection on the tensions' and challenges' impact on the decision-making process. Starting with section 4.1, in this section the political decision arena together with the challenges are discussed. Subsequently, a reflection on Rijkswaterstraat's final strategy is given in section 4.2. Appendix A8 can be used as a source of information.

4.1 Political decision arena

One of Rijkswaterstaat's objectives is to find the best-fit solution for the abundant water in the IJssel while minimising the dissatisfaction with the solution amongst stakeholders and containing the costs of such a solution. So especially for this actor, understanding the political context is of great importance. The conflicting interests amongst the actors could restrict the objective of Rijkswaterstaat. To define any potential tensions and challenges, the objectives of all involved actors will be summarised in the following paragraphs.

The main objective of the Rijkswaterstaat has already been discussed several times in this report. However, a more detailed version with specifics can be found in appendix A5. Objectives of other stakeholders are mostly derived from the meetings held during and prior to the debate exercise. One of Rijkswaterstaat's analyst groups performed an extensive actor analysis, the most important findings will be discussed in this section (Appendix A6).

Based on the actor analysis conducted by Rijkswaterstaat's analysts and private meetings held during the debate exercise, it seems that there are conflicting interests. Starting with the Delta Commission, which has the power to stop a proposed policy from being implemented. At first glance, the Delta Commission's interests are similar to the interests of Rijkswaterstaat. However, the Delta Commission mentioned the importance of a budget. Apart from this deviating objective, both actors desire a long-term solution for the battle against the river with as much support from other actors as possible. The environmental group is mainly interested in the protection of local flora and fauna around the Ijssel. Even though this is most likely of importance for all the stakeholders, the environmental group is the only actor that expressed this concern explicitly. A second actor that is considered a special interest actor is the Transport company, which emphasises their economic value during the meetings. Most of their given objectives come down to remaining operational without delays or uncertainties.

Moving on to the provinces Gelderland and Overijssel, both of them represent the interests of five municipalities combined. They share their main interest, which is the protection of their citizens from the Ijssel. More detailed and specific interests of these political actors will be discussed in section 4.1.2 which will provide an overview of challenges and tensions in the political decision arena.

From the following overview of tensions and challenges, one can sense the complexity of the political decision arena this debate exercise has taken place in. The case at hand is full of deep uncertainties and different problem perceptions amongst the involved actors (Kwakkel et al., 2016). This wicked problem creates the need for compromises on different goals and - as we will see - results in a policy proposal that is not fully in line with the advice offered at the end of this report.

4.2 Tensions, challenges and strategy for Rijkswaterstaat

In contrast to most other actors that could focus mainly on achieving their own objectives, part of Rijkswaterstaat's objectives is to take the interests of all actors into account and to gain broad support for a policy proposal. This means that all the tensions and challenges that arise between actors are important for Rijkswaterstaat.

Starting with the tensions between the set of actors, the interests of the transport company seem to have the least overlap with the interests of other stakeholders. Their main concern is having a minimum water depth of 4 metres (according to them) so that the river remains accessible to their ships. This desire made them extremely critical towards RfR projects. According to the model, RfR projects will cause the water level to decrease, which could cause problems for the transportation sector. The fact that the model does not distinguish between the different RfR projects makes the situation even less clear. There have been multiple meetings between Rijkswaterstaat and the transport company prior to both debates in which the transport company has continually sown doubt about the model's validity. This is something we have immediately attempted to counter by stressing the sole communicative purpose of the model and by referring to our expertise and knowledge, based on years of experience; stating that water depth cannot be negatively influenced by many RfR projects and that the model's results have limited value for this specific issue.

Heightening dikes, however, does not influence the water level, both according to us and according to the model. This made the transport company an immediate and fervent supporter of this solution. However, this solution does not provide more room for nature like many RfR projects (can) do. This creates a conflict with the environmental group's objectives. Making concessions is inevitable in such a complex situation, with this amount of stakeholders. However, safety is not something the provinces and municipalities are able to compromise on. There are tensions between the different dike rings as dike heightening solutions can lower the risk of flooding for one municipality, but as an effect of that the risk increases for another municipality. Such a rise in flood risk is unacceptable for the downstream municipalities.

Then there are the costs associated with all of these projects. This topic had been largely forgotten by many actors in the meetings prior to the debates. However, the Delta Commission does have its budgetary constraints. The origin of the required funding has been rather unclear to many of the involved actors from the beginning onwards. This especially made the municipalities and provinces wary of high costs. In our meetings with these actors, we have constantly focussed on the primary concern, which is safety, thereby shifting the frame (De Bruijn, 2019). The costs should be covered by the state and we have attempted to appease the actors with regards to this topic, as it is something they do not have to be bothered with. This has narrowed down the issue of costs to a conflict solely between Rijkswaterstaat and the Delta Commission, an actor with whom we have maintained a warm and friendly relationship throughout the meetings and negotiations.

The Delta Commission is a crucial actor for Rijkswaterstaat, as it is the only other actor with a right to veto the final policy proposal. Their long-term vision for the Dutch fight against the water has been important for us in determining what to propose. Apart from the aforementioned budgetary constraints, the Delta Commission has to adhere to, they have also set a very strict safety norm. Their demands have been very specific in this regard: a maximum chance of dying due to flooding of 0.001% per person per year within each dike ring. The extent to which the Delta Commission can actually substantiate this or even test policies on this demand is questionable to us. However, it remains crucial to convince them (and other actors concerned with safety) that the solutions proposed by us reach this goal. The model has been a helpful tool in convincing the other actors of this fact.

To summarise, the main topics of concern that cause most of the conflicts between the actors are as follows:

- Local safety levels
- Project costs
- Environmental sustainability
- Transport accessibility

Because of this, we have commenced all the debates with a list of principles that have been the driving factor in all our decisions. With this, we have attempted to create trust and to increase our credibility as a decision-maker that considers everyone's interests.

However, apart from these general issues, many municipalities also have their specific demands. Think of a city like Deventer that does not accept widening of the river because of its proximity to the city centre. We have noticed that the communication between the provinces and the municipalities is not very smooth and both provinces have misinterpreted the preferences of their municipalities. This has come to our attention because some municipalities had directly reached out to us. For this reason, we decided to structure both our policy proposals (the preliminary as well as the final one) for each municipality, one by one. This puts the provinces under pressure to ask their municipalities for feedback regarding our proposal, which happens to be very much in line with the municipalities' individual preferences, as this was our primary priority in finding broad support.

In drafting the actual policy proposal, we have first come up with solutions acceptable to the municipalities. As a result, the provinces should also be willing to accept it. The next step was to test the proposal by running several simulations. We have included relevant model outcomes to show that the policy is in line with the Delta Commission's vision, as well as the other actors' safety demands. This has had an impressive effect on many of the actors, as their understanding and use of the model was limited, despite our attempts to create some common understanding of the model during all of our meetings.

This then leaves us with the demands of both the interest groups. The environmentalists seemed very easily appeased by our sustainable intentions. It was possible to come up with some form of environmental compensation or addition to many parts of our proposal to keep them aboard. The transport company had shown itself a tougher negotiator and kept on creating chaos and redirecting everyone's attention towards marginal topics in the final debate. However, the way we had eventually presented our final policy proposal was sufficient for them to agree to it.

All in all, one could say that we have used a bluffing tactic on some aspects of the debate. Overwhelming the other actors with the level of detail that was part of our proposal created the illusion of total control and understanding. For all the meetings prior to the debates, as well as during the debates themselves, we have constantly stressed our willingness and duty to take all their concerns into account. In the break before the final round of the debate, we had quickly organised several meetings with the provinces and the Delta Commission in order to address their concerns in the final policy proposal. This entailed some small adaptations, an explicit disclaimer and a postponement of a certain intervention, which was all desired by these actors. This was enough to finally make everyone agree and to come to a broadly supported plan.

5. Discussion

Several limitations and assumptions were made during this research, which can be specified using two categories: model-specific assumptions and limitations (1), and research approach limitations (2). Consequently, the used model and exploratory modelling approach can influence political decision-making. Both will be described in this section.

The simulation IJssel River model used for finding the best-fitting policies for Rijkswaterstaat is extensive but does not include everything and therefore several assumptions had to be made.

First, the model has assumed uncertainties but not all uncertain values are implemented. Stirling (2010) warns for the simplification of uncertainties to risks by experts. This means that certain external factors are left out of the model scope. For example, government changes, terrorist attacks, extreme weather events, and other unforeseeable events have not been taken into account.

Second, the calculation of outcomes of interest is based on assumptions. The cost functions are based on 1995 data, it is questionable whether this data is still valid. Also, the damage is measured in terms of costs, which is solely the physical effect of damage. Social costs such as emotional and psychological damages are left out of the model scope. Taking the emotional and psychological damage more into account in the model could alter the final outcomes.

Next, the limitations and assumptions made during the research approach are discussed.

Due to the lack of computational power of the computers used during this research, a limited number of experiments is run. Outcomes of the analyses could differ when more experiments are taken into account. Consequently, because of time and computational power limitations, only the most relevant analytical methods from the EMA Workbench are performed during this research for Rijkswaterstaat in the IJssel case. Specifically, next to the conducted MOEA, this research can be extended with Many Objective Robust decision-making (MORDM), a framework for finding and evaluating policy spaces under multiple objectives (Watson & Kasprzyk, 2017).

Optimisation is conducted using the problem formulation for aggregated outcomes of interests, to see which policies would be the best based on the fact that the Rijkswaterstaat wants an aggregated optimal solution. However, Rijkswaterstaat has a high interest in achieving a solution space that is the best for all but also to get support from the different municipalities. During the EMA analysis the goals and interests, which could not be measured by the model, of the municipalities are not taken into account.

Furthermore, the outcomes of the MOEAs, the ‘best’ policies, are based on the extreme values of a worst-case scenario. When interpreting the result of this analysis it is very important to bear in mind the fact that these outcomes might not be very realistic.

6. Conclusion

The goal of this research is to propose a policy strategy for the protection of the IJssel River region against flood risk. This chapter will answer the following main research question: "*What policy strategy results in favourable outcomes, even if a worst-case scenario occurs, that will satisfy all actors and could thus be implemented in the current political situation?*". To answer the main question six sub-questions will be answered.

The first sub-question to answer is the following: "*Which uncertainties influence the outcomes of interest the most?"* To answer this question open exploration, with random sampling, was used as a technique. First, the failure of dike 3 has the highest impact on evacuation cost, expected number of deaths, and expected annual damage. Therefore, more attention should go towards this dike. Moreover, dike failure has the highest impact on the outcomes of all uncertainties. If total cost avoidance is the main focus, dike 1 and 3 seem to be the most important. Therefore, if high-cost avoidance is a priority more resources should go towards these two dikes.

The second sub-question is: "*What would happen at worst to Rijkswaterstaat and the IJssel river area if no flood protection or mitigation measure would be implemented?"* To answer this question a PRIM analysis is conducted to find the worst-case scenario with no implemented policies. One can conclude from this analysis that the expected annual damage and the expected number of deaths are relatively high. As safety is crucial for Rijkswaterstaa, not taking any measures is no option, therefore measures will be necessary to provide safety to the citizens in the IJssel River region.

The third-subquestion is the following: *"What is the most favourable policy strategy in terms of expected deaths and costs?* To answer this question the worst-case scenario is taken as the starting point for the exploration over policy levers. One can conclude from the results of the analysis, that a trade-off is existing between the investment costs of dike heightening, expected deaths and room for the river investment costs. It appears that dike heightening results in fewer deaths, consequently higher room for the river results in fewer deaths. Nevertheless, both higher dike investments and higher room for river investments is an unfavourable solution, because of the high investment costs. In total, 42 possible policies were found that were most favourable for the outcomes. These policies lie in the solution space with the boundaries 0.01 - 0.60 expected deaths, 0.00 - 13697782.46 dike investment costs and 0.00 - 638600000.00 RfR costs. This supports the previous statement that investments are made either for the room for the river or for investments in the dikes.

The fourth sub-question is: *"How undesired will the outcomes become, in case insufficient policies are implemented?".* This question is answered using directed search as a method. In the found worst-case scenario if an insufficient policy is chosen the model predicts the following values for the selected outcomes: the number of expected deaths is 3.52, Dike Investment costs will be 547 million euros, and RfR investment costs are expected to be 1203 million euros.

The last subquestion is the following: *"What is the effect of the political context on the implementation of this report's advice?"* From the political reflection, we can observe that the complex nature of political reality as we have experienced during the debates can influence the extent to which this report's advice can be fully adhered to. This multi-actor problem is characterised by deep uncertainties and competing interests, which creates the necessity for compromises. Especially considering Rijkswaterstaat's mandate and goals, the final policy proposal has been drafted to reach a broad support base as a top priority.

Making concessions is inevitable in such a complex situation, with this amount of stakeholders. However, safety is not something the provinces and municipalities are able to compromise on. We advise that involvement of stakeholders is necessary, therefore it is important for Rijkswaterstaat to persuade the stakeholders about the importance, effectiveness and efficiency of the proposed policy measures.

With the described information it is possible to answer the main research question. For Rijkswaterstaat, according to the model, 42 policy options have been found. From the analysis, one can conclude that both investing in RfR and dike heightening is not efficient and not necessary. Dike 1 and dike 3 are the most critical dikes in terms of the expected number of deaths. Therefore, Rijkswaterstaat is advised to invest in dike heightening of the dikes 1 and 3 (7 and 8 cm) if chosen for dike heightening.

To conclude Rijkswaterstaat should keep in mind that the results described in this report are meant to be used for decision-making support when making decisions under deep uncertainty. With the exploratory modelling, different futures were explored and a lot of uncertainties are taken into account. Nevertheless, the above-described limitations can result in a difference of outcomes. Therefore, the outcomes of this research should not be seen as predictions of the future.

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A. Appendix

A1. Pairplot of the outcomes - Base scenario

In this figure, a pairplot is visualised for all outcomes, for each dike ring separately. In this situation, no policy is yet used, thus it represents the base scenario. Correlations between various outcomes are visible.

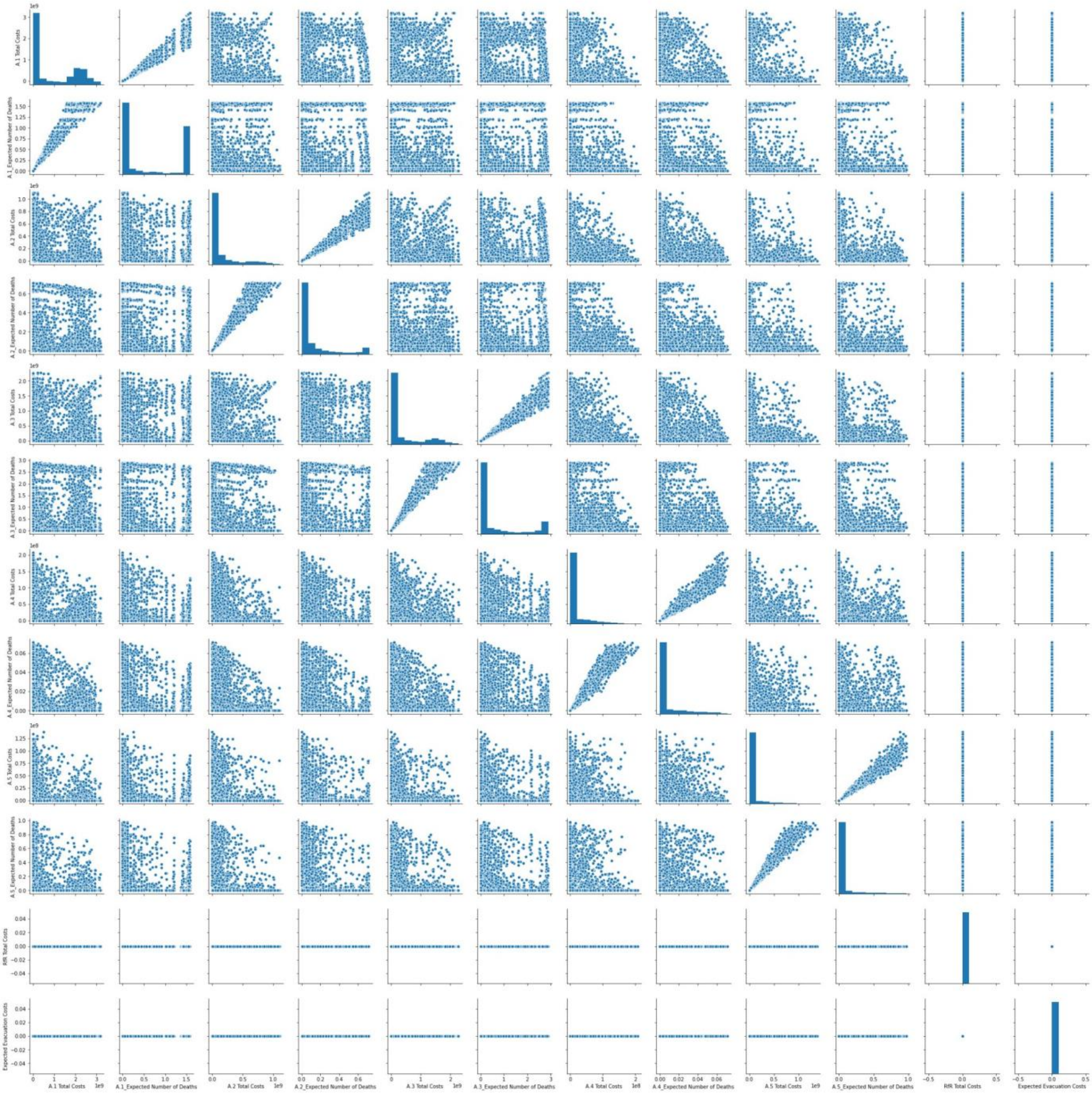

Figure 9: Pairplot for all outcomes based on a base scenario

A2. Feature scoring - Base scenario

In this figure, the results of the feature scoring are visible. This represents the influence each uncertainty has on the outcomes. Again, this is done for the base scenario.

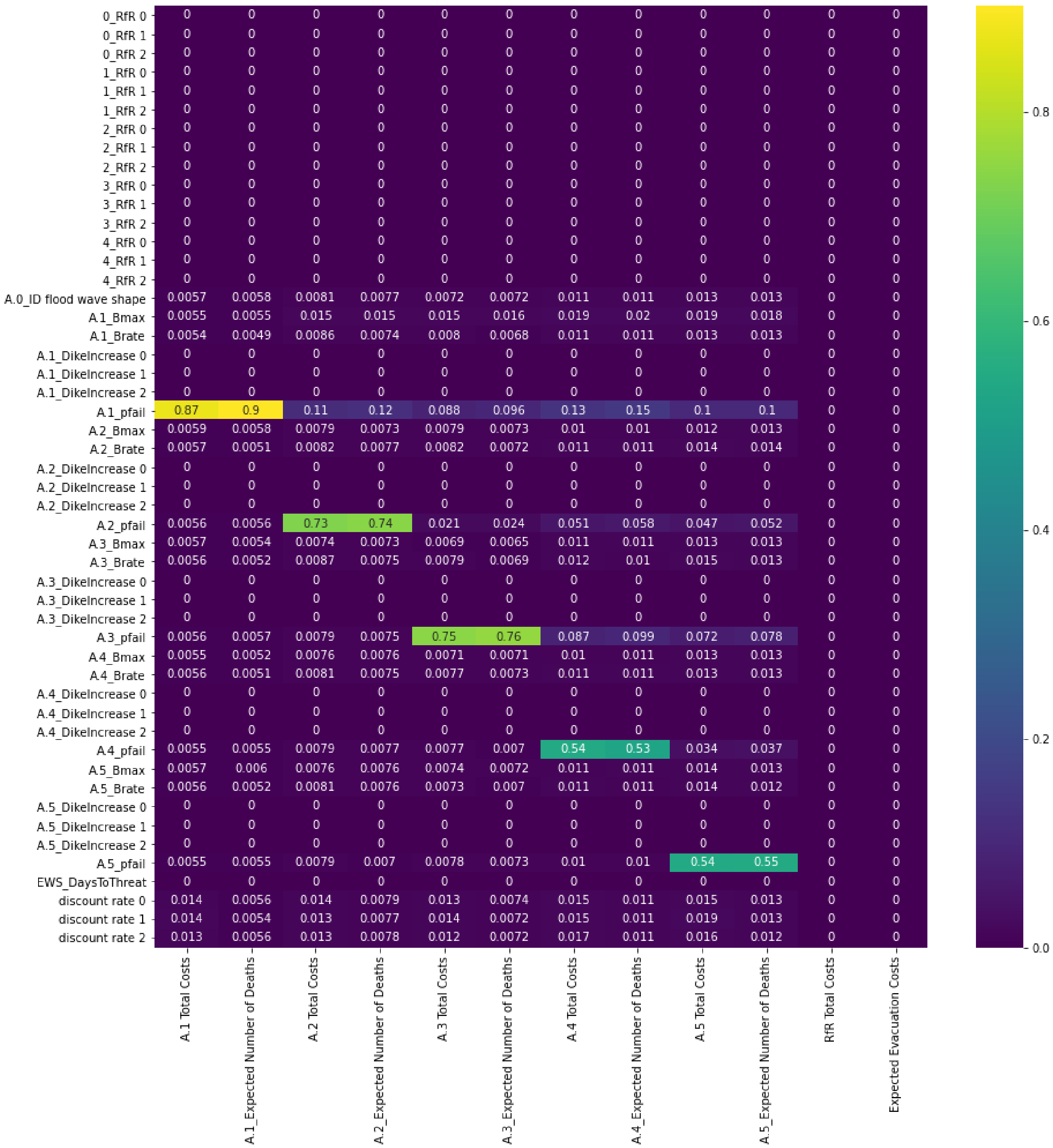

Figure 9: Feature scoring for uncertainties and outcomes based on a base scenario

A3 Pairplots of outcomes - Random Sampling

In this figure, the correlation between different outcomes can be derived. Five outcomes are visualised, aggregated over all dike rings. In this situation, random sampling was executed over different strategies, with all policy levers set at random values.

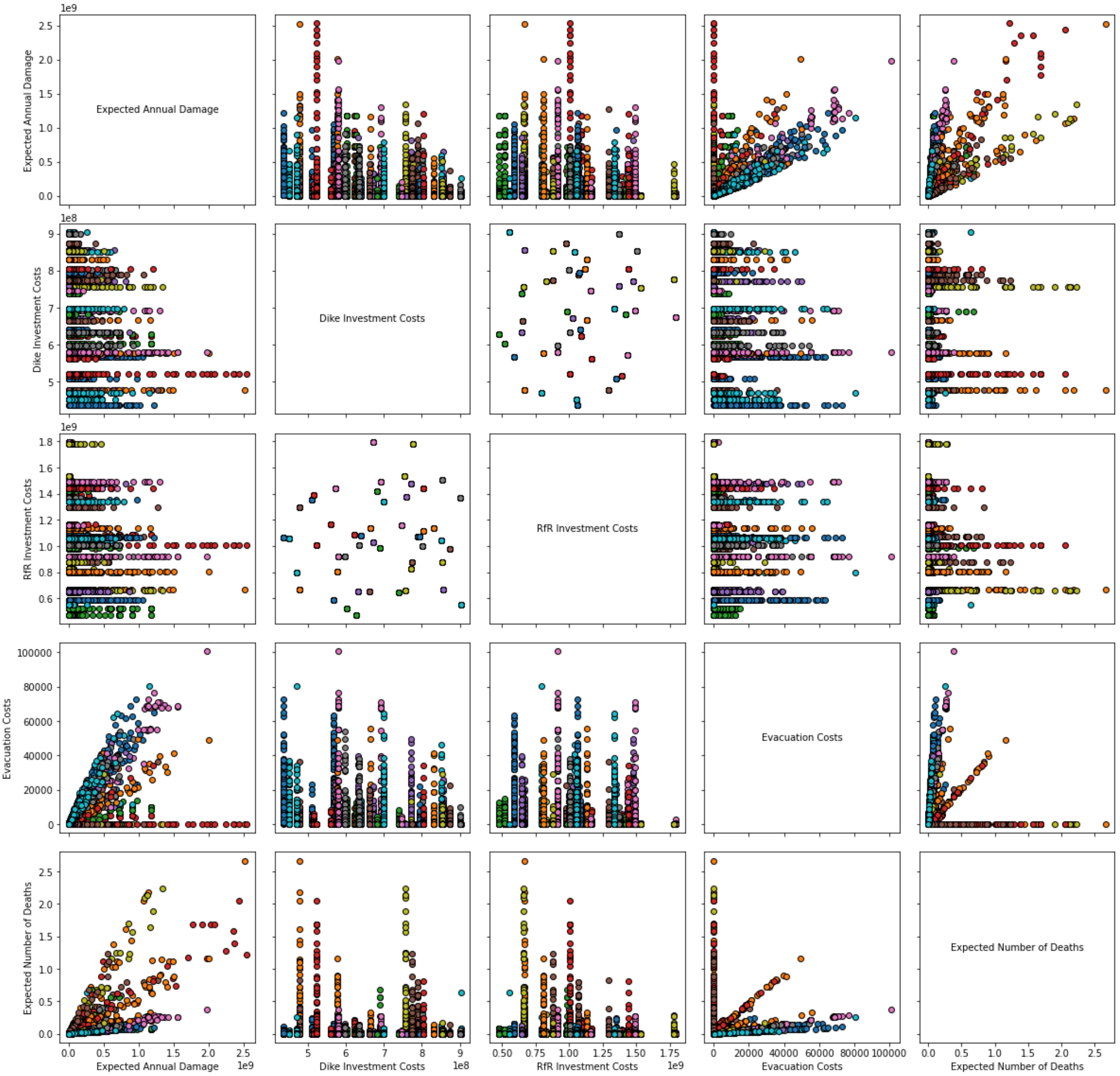

Figure 11: Pairplot for outcomes aggregated over locations based on random sampling

A4. Epsilon convergence plots optimisation

In these figures, the epsilon convergence plots for the optimisation are visualised. From these figures, it can be derived after how much function evaluations the optimisation starts to converge. In the first two figures, the results of optimisation over the levers are visualised. The best and worst policies are investigated, respectively. As can be seen, the optimisation has not completely converged yet for the current amount of function evaluations. However, due to computational and time constraints, the optimisation was still put to a stop.

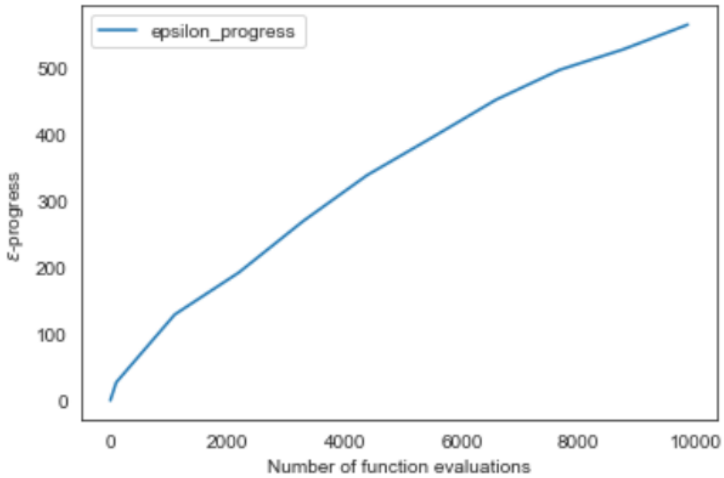

Figure 12: Epsilon convergence plot for optimisation over levers to find the best policies

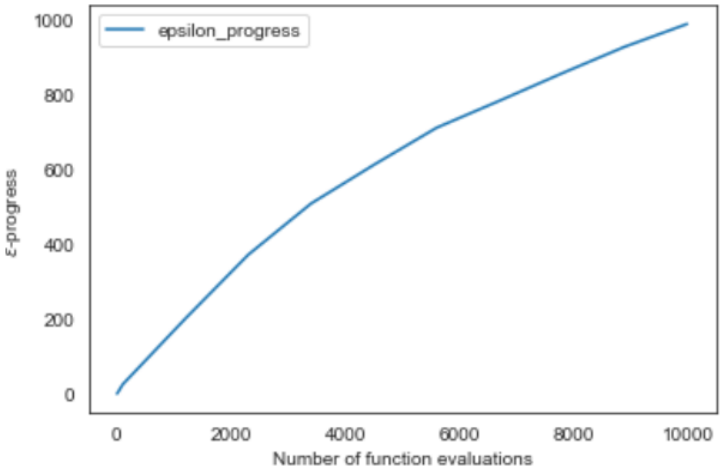

Figure 13: Epsilon convergence plot for optimisation over levers to find the worst policies

In the figures below, the epsilon convergence plots for the optimisation over the uncertainties are shown. Respectively, the plot for the search for the worst-case scenario for the best policy and the worst policy is visualised. For this search, the optimisation did converge already for the chosen number of function evaluations.

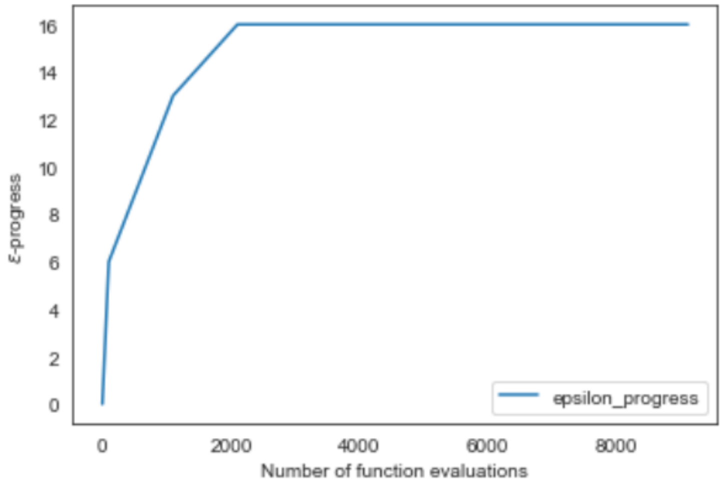

Figure 14: Epsilon convergence plot for optimisation over uncertainties to find the worst-case scenario in case a random policy is chosen from the best options

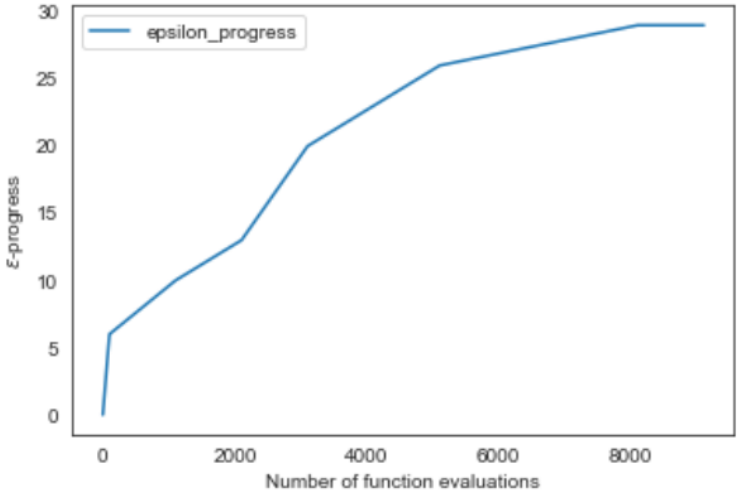

Figure 15: Epsilon convergence plot for optimisation over uncertainties to find the worst-case scenario in case a random policy is chosen from the worst options

A5. Policy lever values for best and worst policy

The policy lever values corresponding to the best and worst policy found for the worst-case scenario, respectively, are visualised in the tables below.

Best Policy

Lever	Value
0_RfR 0	0
0_RfR 1	0
0_RfR 2	0
1_RfR 0	0
1_RfR 1	0
1_RfR 2	0
2_RfR 0	0
2_RfR 1	0
2_RfR 2	0
3_RfR 0	0
3_RfR 1	0
3_RfR 2	0
4_RfR 0	0
4_RfR 1	0
4_RfR 2	0
EWS_DaysToThreat	3
A.1_DikeIncrease 0	7
A.1_DikeIncrease 1	0
A.1_DikeIncrease 2	0
A.2_DikeIncrease 0	0
A.2_DikeIncrease 1	0
A.2_DikeIncrease 2	0
A.3_DikeIncrease 0	8
A.3_DikeIncrease 1	0
A.3_DikeIncrease 2	0
A.4_DikeIncrease 0	1
A.4_DikeIncrease 1	0
A.4_DikeIncrease 2	3
A.5_DikeIncrease 0	0
A.5_DikeIncrease 1	0
A.5_DikeIncrease 2	0

Worst Case Scenario Best Policy

Uncertainty	Value
discount rate 0	Category('3.5', 3.5)
discount rate 1	Category('3.5', 3.5)
discount rate 2	Category('1.5', 1.5)
A.0_ID flood wave shape	51
A.1_Bmax	188.5889381
A.1_pfail	0.740973404
A.1_Brate	Category('10', 10)
A.2_Bmax	111.0210981
A.2_pfail	0.999992914
A.2_Brate	Category('1.5', 1.5)
A.3_Bmax	254.7247613
A.3_pfail	0.994103988
A.3_Brate	Category('10', 10)
A.4_Bmax	310.4425016
A.4_pfail	0.981501809
A.4_Brate	Category('1.5', 1.5)
A.5_Bmax	240.2595555
A.5_pfail	0.999748289
A.5_Brate	Category('10', 10)
Expected Number of Deaths	0
Dike Investment Costs	63768092.02
RfR Investment Costs	84600000

Worst Policy

Lever	Value
0_RfR 0	0
0_RfR 1	0
0_RfR 2	0
1_RfR 0	1
1_RfR 1	0
1_RfR 2	1
2_RfR 0	0
2_RfR 1	0
2_RfR 2	0
3_RfR 0	0
3_RfR 1	1
3_RfR 2	0
4_RfR 0	1
4_RfR 1	1
4_RfR 2	1
EWS_DaysToThreat	0
A.1_DikeIncrease 0	1
A.1_DikeIncrease 1	3
A.1_DikeIncrease 2	9
A.2_DikeIncrease 0	5
A.2_DikeIncrease 1	8
A.2_DikeIncrease 2	5
A.3_DikeIncrease 0	0
A.3_DikeIncrease 1	0
A.3_DikeIncrease 2	0
A.4_DikeIncrease 0	4
A.4_DikeIncrease 1	0
A.4_DikeIncrease 2	10
A.5_DikeIncrease 0	9
A.5_DikeIncrease 1	3
A.5_DikeIncrease 2	2

Worst Case Scenario Worst Policy

Uncertainty	Value
discount rate 0	Category('2.5', 2.5)
discount rate 1	Category('1.5', 1.5)
discount rate 2	Category('4.5', 4.5)
A.0_ID flood wave shape	123
A.1_Bmax	30.03342437
A.1_pfail	2.27E-10
A.1_Brate	Category('10', 10)
A.2_Bmax	30.11529837
A.2_pfail	1.37E-08
A.2_Brate	Category('1.5', 1.5)
A.3_Bmax	115.2997283
A.3_pfail	0.005433633
A.3_Brate	Category('10', 10)
A.4_Bmax	194.9204836
A.4_pfail	0.435535212
A.4_Brate	Category('1.5', 1.5)
A.5_Bmax	142.34388
A.5_pfail	0.00020593
A.5_Brate	Category('10', 10)
Expected Number of Deaths	3.515773422
Dike Investment Costs	547390948.6
RfR Investment Costs	1203900000

Figure 16: Best and worst Policy values and outcomes

A6. Rijkswaterstaats main objectives

You are part of the Ministry of Infrastructure and Environment and your mandate is clear: Practical execution of water management and public works. You are an administrative body that is tasked with designing (and later implementing) the policy for flood management on the Ijssel river. You have the following agenda:

1. Propose a policy that is robust, in line with the political vision of the Delta Commission, and has enough support to be adopted. You also place a very high premium on having all actors approve the policy and will try to avoid any ‘no’ votes.

2. You have been under increasing political pressure to deliver actual policies, which means that you really want a policy to be approved by the end of the final debate and you want this policy to be as specific as possible (specific interventions rather than agreement on future deliberation and priorities)

3. You are extremely receptive to empirical evidence and do genuinely want ‘the best possible’ policy. (B.A. Jafina, personal communication, May 7, 2021)

A7. Other actors' objectives

This appendix will describe all the stakeholders with their interests and goals regarding the RfR project. National and regional governments, the general public and the business community are involved in the political decision arena. More specific:

- Environmental Interest Group (special interest actor)
- Transport Company (special interest actor)
- Delta Commission (political actor)
- Province of Gelderland (political actor)
- Province of Overijssel (political actor)
- Rijkswaterstaat (administrative/technocratic actor)
- Dike rings 1 & 2 (rural, in Gelderland) (combination of political and administrative actor)
- Dike ring 3 (urban, in Gelderland) (combination of political and administrative actor)
- Dike ring 4 (rural, in Overijssel) (combination of political and administrative actor)
- Dike ring 5 (urban, In Overijssel (Deventer)) (combination of political and administrative actor)

Actor	Interest	Problem perception	Goal/objective
Environmental Interest Group	Protection of local flora and fauna around the Ijssel	Resulting in an outcome in which environmental impacts are not considered/are compromised by economic and safety improvements.	• Finding a solution that is resilient in terms of water level and water quality. • Minimise the obstruction for animal movement and corridors. • Minimising soil erosion • Providing sufficient habitat for a local flora and fauna
Transport Company	Transport via the Ijssel	If the Ijssel will have more room/floodplains this results in a lower water level. The water level might drop to a level in which the fairway is too shallow for transport resulting in delay and uncertainties for the transport company.	• Minimisation of obstacles that will cause delay for transport. • Deep enough fairway in the IJssel to optimise transport. • Minimisation of construction activities that will result in any delay for transport.
Delta Commission	Providing a safe and durable water infrastructure for the Ijssel on long term	Maintaining a neutral role while aiming for progress	• Find a solution in which the interests for all actors are considered. • Fulfilling the role of the mediator in which actors find consensus in their solution.

Province of Gelderland	• Optimising economic activities • Protecting the citizens from the Ijssel	Optimising safety for her citizens without this resulting in less opportunities for economic activities	• Providing safety for her citizens by minimising the changes of a flood occurring (safety measurement) • Proving safety for her citizens by minimising the effects when a flooding accident occurs (security measurement) • Providing a sustainable, economic environment
Province of Overijssel	• Optimising economic activities • Protecting the citizens from the Ijssel	Optimising safety for her citizens without this resulting in less opportunities for economic activities	• Providing safety for her citizens by minimising the changes of a flood occurring (safety measurement) • Proving safety for her citizens by minimising the effects when a flooding accident occurs (security measurement) • Providing a sustainable, economic environment
Rijkswaterstaat	Executing organ of Ministery of Infrastructure and water management		• Find a solution in which the interests for all actors are considered. • Find a solution that is in line with the vision of the Delta Commission

Dike rings 1&2 (Rural)	• Protecting the citizens from the Ijssel • Provide enough room for agriculture activities.	• Occasional occurring of a flooding provides fertile soil and is therefore beneficial for agriculture activities. • Increasing room for the river would mean less room for agriculture activities.	• Providing safety for her citizens by minimising the changes of a flood occurring (safety measurement) • Proving safety for her citizens by minimising the effects when a flooding accident occurs (security measurement) • Providing enough room for agriculture activities
Dike ring 3 (Urban, Zutphen, in Gelderland)	• Protecting the citizens from the Ijssel • Provide enough room for urban development and (agriculture activities.)	• Providing a safe environment for her citizens is most important but not at the expense of urban development or agriculture activities.	• Creating a plan for the coming years to keep the city from flooding. • Concessions are possible, but they must be sensible. Not moving 1000's of citizens for a few cows.

Dike ring 4 (Rural, Gorssel, in Gelderland) *Natura 2000 area.* *The loss of land is more of a danger than the water now.* *Protect the land they have right now (for both agriculture and the bio-diversity).*	• Provide enough room for agriculture activities. • Maintaining the current natura-2000 area • (Protecting the citizens from the Ijssel)	• Occasional occurring of a flooding provides fertile soil and is therefore beneficial for agriculture activities. • Increasing room for the river would mean less room for agriculture activities and encroach on the natura 2000 area.	• Providing safety for her citizens by minimising the changes of a flood occurring (safety measurement) • Proving safety for her citizens by minimising the effects when a flooding accident occurs (security measurement) • Providing enough room for agriculture activities • Maintaining the current natura-2000 area
Dike ring 5 (Urban, Deventer)	• Protecting the citizens from the Ijssel *'All we care about is the safety of the people in our city'*	Providing a safe environment for the citizens is most important, but would favor a solution in which they don't have to relocate citizens	• Ensuring the safety of the people in deventer

A8. Debate minutes

In this appendix are the minutes of the debate given. This can be used as a source of information for the political reflection.

Start presentation Rijkswaterstaat

Rijkswaterstaat:

We have done a proposal. Thanks for being here. It is important you all contribute, for the safety of our population

5 keypoint:

- Prevention lose of life
- Prevention of damage
- Prevention of floods
- Environmental sustainability
- Transport capability

Expected costs: 3 billion [2.2, 3.7]

Deaths [3 a 4]

Doesburg:

Most critical

Proposal: construction of high water channel

Costs will be limited, good for the area, also recreation, which Doesburg likes

Concerns about lose of land. But is limited we think

Cortenoever

Low risk area

Dike heightening is fine, and safe

Focus on weak points of existing dikes

Within cost budget

Zutphen

Dangerous position

West is possible to relocated dikes for birds and insects

East needs strengthing

Estabilishing nature areas, add to sustainability

Gorssel

Relative favourable position, safe

Stricter evacuation plan is nice, early warning

But no physical measures

Deventer

Relatively safe

Deepening the Ijssel is favourable, by Transport, since doesn't limite the viability

With Transport need to further discuss this project in detail

Rijkswaterstaat likes a monitoring system here

Safety standards most be reach though

Total costs: RFR 1.1 billion, Total dike costs improvement: 304 million

Back to moderator

Environmental:

Thanks for proposal.

- In Gorssel, what are your plans for butterflies?
- What about the monitoring plans

It's especially for animal monitoring. In Gorssel no further plans are necessary, so we want to let nature grow on its own. This is in the benefit of animals, like bees.

Elie – Gelderland:

- Is there a limit in the budget?

Delta is going over the budget, Rijkswaterstaat doesn't thinks it is going to be more than the available project.

Delta: Budget is 6.5-8 billions in the Netherlands (14-15 years). Room for the River is one subject in this. Deeping rivier is more expensive than strengthing dikes, Delta likes to talk about it later. This information was brought to Delta by Transport (who prefere Dikes though).

- You did quite resource, we do a proposal. To compensate for the m^2 that need to be taken up by the river, and pay for it. Also to compensate farms. This is in Doesburg.
    - Rijkswaterstaat: Only 2 farm componies are dubbed, we compensate them. We are in contact with the Government and want to integrate nature and animals more in the area.
    - Gelderlands want to verify this information. Zuthpen is quite dangerous area. Zeeland was flooded ones, heightening dikes was done.
        - There is a diffence in protecting against the sea or Ijsel (Rijkswaterstaat)
        - (Delta) Zeeland is whole other part of the Netherlands
        - (Gelderland) We cannot continue to give land to the river, in such a easy way. No the risk of flooding is low, but we have environmental problem of global warming, so in the future, flooding will occure more and more. So more floods, will mean more land to be taken in the sea. How to compensate for this land lose, also by the inhabited.
        - (Rijkwaterstaat) We have taken all factors in consideration. The history learned us heightening dikes is also dangerour, we cannot heighten dikes everywhere, room for the river is important.
        - (Delta) Yeah we should consider people losing there lands, but the condition in Zeeland was a whole other situation. We should keep the discussion to this IJssel project

Transport:

Commerce does not have a very big importance in your proposal. We feel unheard in the commercial aspect, also in the agricultural sector and provision of jobs.

Deeping the rivier is import for the future of the Netherlands. Let us be pro-active, and invest in deeping riviers, to stimulate the economy as well.

- Rijkswater: We agree, we shall repeat the commercial importance more often. But we did take it into account. We located dike in a way that it is not lower than 4 m, so you should not be worried that your companies can not continue their jobs.

OverIJssel:

We are interested in the Transports plan to deepen the river in Deventer. What will change there according to you (Transport).

- Transport: The deeper the river, the larger the boot can be, so more eco-friendly
- Overijssel: The size of boats, mean different measures for safe passing?
- Transport: safety is priority of Rijkswaterstaat of Delta. Look at our manual (in a sort western voice form a cowboy)
- Rijkswaterstaat: Deeping river is not part of the plan now. Maybe further discussing later one-on-one
- Delta: Concenerns are on deeping rivers, to environmental (what about the impact of environment by deeping?). Deeping is not possible in the model, with is sad. We found that the cost for deeping in Deventer is twice the cost of Heigthing dikes, without taking more risk, so no extra risk of deaths. Twice as much is a lot, so we don't want to give so much money if not necessary
- Rijkswaterstaat: In Deventer, it is difficult to heighten dikes, since the city center is so nearby the Dikes, so that's the main reason to not do that.
- Delta: We know why you choice for this, but who is going to pay for this?
- Rijkswaterstaat: We have some special funds for this
- Transport: These costs are an investment, that later on stimulate transport, commerce and will be repaid via economic growth.
- Delta: We have to find the appropriate data to make responsible choice. Why is this investment so important? Also in comparison to other Transport options.
- Transport: There is not enough data available, and that's your responsibility
- Gelderland: We agree with Transport, Delta seem to have a collaboration with Rijkswaterstaat. You don't listen to us!
- Transport: we want to give back to farmer, more economic prospects, not blame them but give them. Not take their land away.
- Rijkswaterstaat: Gelderland you give the impression we don't listen to you. But we do. We took your interest in account. Voice your concerns as concrete as possible please.
- Gelderland: I didn't knew you had contact with farmers as well. If I look to the stakeholders in my region, we disagree with you.
- Rijkswaterstaat: Lets later discusse this.

Environment:

Huge discussion about conceding land, while it is also important to give back to nature. Room for the river projects are good for this. We don't fight nature, but give room to it. We are concerned about farmers as well, but also for farmers Room for the River is important, or an opportunity. Also for tourism, or new work, of a healthier life style.

- Gelderland: How can people live on the land, if it is given to the river? Offcource we agree that nature is important. But the governments are already small, the farmers lose already a lot of land.
- Transport interrupts
- Overijssel: There is some uncertainty about this land taking by farms, we need more information about this, otherwise we could not agree with the proposal.
- Rijkswaterstaat: Lets do a meeting with Overijssel, Gelderland and us.

Delta:

- We want rivier deeping in Deventer maybe (lot of people want this). Maybe we should follow transport in this. We need to thinks about this in the break
- About conceding land, we agree that this contribute to the nature, and safety. Delta wonders to Gelderlands, that the can find an intermediate solution.

-----Pauze----

Overijssel: wil niet groter of vaker schepen (Deventer wil dat niet). Transport wil zich soort van inkopen daar, door te helpen om mee te financieren, maar dan grotere schepen erin.

Gelderland: wil compensatie boeren. Rijkswaterstaat: Het gaat over 3 km^2 land, we zullen jullie compenseren.

DEEL 2:

Gelderland: We had contact with the munipalities and Rijkswaterstaat. We were suprised by the farmers communication, but got the details from Rijkswaterstaat on this. We made an agreement; only if the land is compensated, we agree. If that compensation is done, we are oke. Zutphen want an compensation of 1.5 times the prize instead of 1 time.

Rijkswaterstaat: Selling land is outside the provinces legislation. The nature area is a true addition, recreaction is nice. We are able to pay 10 times as much money for the land going to the river, so the 1.5 times is agreeable by us. We are glad we come to an agreement than.

Gelderland: It implies 15 million euros at Doesburg. Could you say how much you are going to compensate?

Rijkswaterstaat: The companies, will accept the 15 million, and we will cover the recreation area realisation cost.

- Delta: Is everyone happy in Doesburg or Kortenoever? Than we can close this chapter.
- Environment: What costs are these by companies? Does that imply a lot of new buildings? Or is it purely for nature?
- Rijkswaterstaat: It is argicultural area, two argi-companies that are going to be bougth out. So it is vegitation, woods, animal, no large infrastructure.
- Environment: We would like to see the plans for this. Also for the waste regulation, animal protection ect. and monitoring this. To ensure the future generation is safe.
- Rijkswaterstaat: We will come up with a plan for this.

Gelderland: Will you compensate for Zutphen the 1.5 times worth of land, 15 mil euro.

Rijkswaterstaat: Yes we will, and stimulate biodiversity in the area with extra costs.

Delta: Are you already talking about the Room for the river cost in it?

Rijkswaterstaat: only the buying out, and relocating of farms. The room for the river is still extra money, also for deeping the river.

Environmental: How much money is there for nature? But like the idea

Rijkswaterstaat: We are aware of your concerns,

Transport:

Compensation for farms is handed out. We would like that any interruption in our schedule is compensated with a 1.5 times the costs.

Rijkswaterstaat: We have legislation regulations for this compensation regulations. And have a look at it.

Transport: We agree on 1.5 time cost compensation?

Rijkswaterstaat: Ministerie Finance will take care of this any further.

Delta: How much money do you expect to come from other governmental funds?

Rijkswaterstaat: Can not command on, ministery of Finanace responsable

Rijkswaterstaat:

Overijssel you had some issues? about tranport company that would like to vessel larger ships. We would like to state that a deeper level, would give the transport company the rights to use larger ships or drive more frequently due to (law) restrictions, safety regulations. So this is NOT a free pass, for larger ships.

Overijssel:

We agree, we hope to find a agreement with transport. But for now no bigger boats is nice.

Transport:

We intent to apply more environmental vessels, in extent of the law. At this time we have no further information.

Delta:

- What is the status of river deeping?

What are the costs? How are we going to cover it (if we are able to model this). But we think we cannot model this, so are we talking bull shit now? What do we know and what know?

Rijkswaterstaat:

We have good estimation. Multisampling.

Delta; we found a budget of slightly less than 2 billion, without room for the river in Deventer.

Rijkswaterstaat: we could joing our analysist, but even if it is 2 billion it is in the available budget.

Delta:

Room for the river is not favourable, since it is way more expensive than dike heigthening. We need to now the benefit, before agreeing on this amount of extra costs.

Transport:

How and in what way do you include draggening? Maybe this can explain the difference between your Delta and Rijkswaterstaat budget.

Delta:

Dragging is standard included, regardless what we choice, so it is not relevant for the debate.

Overijssel:

We heard a proposal of doing nothing. If we not have deeper river, peoples safety here is not guaranteed.

Delta:

Getting more info about the effects of deeping the river for the down stream cities, will take at least half a year to fully look into the effect. We would like to do more research. Deeper river, will mean higher capacity and more water. We need to first study this effect. Because it is not in the model.

Model does not include effect in down stream cities, the effect of upstream cities.

Overijssel:

We have analysist looking into the effect of deeping the river.

Rijkswaterstaat:

Zwolle en Kampen are downstream, and we get that does are also important, but they do not contribute in this debate now or in this dike project. We know that they prepared on there own.

Transport:

Yes room for the river has a lot of uncertainty. I think about deeping river ,and replacement of dikes, by room for the river. (perspective) So what do you mean with Room for the river.

Rijkswaterstaat:

At some places it is relocating, at some strengthening, it depends as stated in the proposal.

The down stream effect are almost the same for all room for the river project choices.

Environmental:

Lets open up mind (for deventer). Think about environment really gets place, also the nature.

---BREAK-----

Final Proposal by Rijkswaterstaat

Doesburg:

still the same

Most criticall

high waterchannel lange ijssel en dierensehank (dooded lines)

Three argi companies, we made a deal with them. To pay 10 time the market price, 150 million costs.

Northen farmer does not want to cooperated, we leave that be, he is able to continue its busnisses.

We have a picture of have the reactional area is going to look like.

Flora and Fauna is cared about, absence of green house gasses of farmes who were first there.

Kortenoever:

Low risk

Prefer dike heightening, which is safe

min water level not effect

aim for weak spots

Zupthen:

East we do strengthening

West relocating of dikes

The space nature will be left alone.

We will pay 1.5 time price of land, to establish room for animals or trees (sustainable)

Gorssel:

low impact area

No physical measures needed

Early warning system will do

Deventer:

Relatively safe position

No regulation needed, but due to concerns we agree on deeping the Ijssel here.

This migth give the idee that we give Transport a free pass, what is going to cost the living area. But Transport need to comply to regulations, we have not given extra permits for vessels or so.

Downstreams will be safe

With our prior experience, even if the water flow will raise, we make sure we will take care of safety of lower downstream municipacties. We will further investigate the effects with the Delta commission, we later starting working in Deventer to ensure safety for the furture genations.

Total cost: 1.1 billion

Total dikes 304 million.

VOITING:

- Overijssel: Yes
- Delta: Yes
- Gelderland: Yes
- Transport: Yes
- Environmental: Yes

Reflection from TA:

- unclear what the main issue is, lot of issues (unstructural).
- model is still incomplete (limited)
- lots of actors, people start complicating it even more
- even more actors got involved, broaden the problems (realistic)
- sometimes new options pop up, (market options ect.)
- need for more research

- environmental en transport could be added in the model, but thats model choice, we cannot model everything

- what do you want to get out of model? optimalisation or trade-offs in options? and stimulate debate?

Jan Kwakkel:

Congratulations. Most years people fail to achieve an agreement. It was interesting that you keep room for negotiations in the future. Time as a way of resolving negotiations. Smart. Flexible strategies.

Also intriguing that you focus on the model a lot. Normally it is more about the interest. Talking about the model while not all interest are included is always difficult, and you can expect attacks on that, which also happend.

There was a lot of negotiation nonsense. How do ships get to Deventer, if the rest of the river is not deep enough haha. This happens in reality as well. People focus on model only and the compensation, but forget the full picture.

So even if you have the model, translate it to reality, think broader besides the model.

I hope you enjoyed it.

Practical things:

- I wasn't planning on doing extra Q&A

- lab session continues (monday late)