Social feasibility of solution directions for sea level rise

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by

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Summary

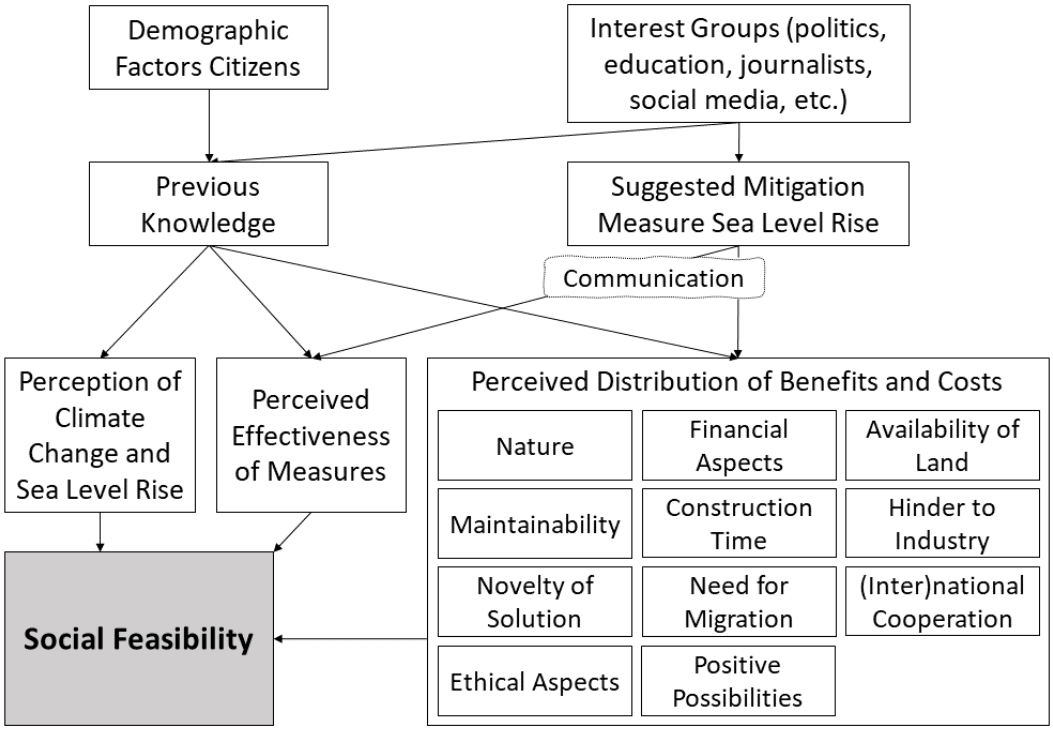
The flood protection system in the Dutch Delta has to be adapted to accommodate the rising sea levels. This can be done in different ways. This thesis focused on four potential solution directions: protect, seaward, move along, and a combination of these directions. An important factor in the decision-making is the opinion of citizens on different potential solutions as a solution must be socially feasible to limit the backlash it receives; no academic literature on this could be found. Furthermore, an interesting aspect on this topic is the potential difference in opinion between different generations as there is an uneven distribution of the responsibility and impacts of sea level rise amongst generations. In literature, differing opinions were present and thus no consensus was found. Therefore this thesis aimed to fill these knowledge gaps and aimed to assess the social feasibility of solution directions for sea level rise amongst different generations in the municipality of Rotterdam.

The research consisted of different steps. First, social feasibility was conceptualised through literature research. After this, the social feasibility amongst different generations of citizens who live in or near Rotterdam was assessed. Finally, the conceptual framework for social feasibility was adapted according to the findings from the interviews and the academic and social implications of the findings were assessed. As the research was explorative, a qualitative research method was used. This consisted of a combination of literature research and interviews. The initial conceptual model for social feasibility was made by adapting the framework of Feitelson and Salomon to fit the context of potential solutions to sea level rise. The social feasibility of citizens in/near Rotterdam was assessed through interviews. The interviewed citizens fell into two age categories: 16-30 and 60+. After analysing the findings from the interviews, the conceptual model was adapted to better fit the results.

The findings indicate that all discussed solutions are socially feasible. Of the three solution directions, most interviewees preferred the protect strategy, followed by seaward and move along. However, almost all interviewees preferred the combination of the solution directions. This was somewhat expected as the combination was explained in more detail which made it seem more thought through and could give a clearer picture of the impacts. The combination was also seen by nearly all interviewees as having a good distribution of benefits and costs, this is likely because it is more balanced than the separate solution directions. Even though each solution is thus socially feasible, there is an important precondition for a solution to sea level rise; namely, that there is a clear plan for how the new situation is going to look including the technical, financial, environmental and otherwise important aspects.

Regarding generational differences, it is interesting to see that the 60+ group on average dislikes the move along direction, whereas this is relatively popular in the 16-30 year group. Amongst the 60+ group, the move along direction is also not socially feasible; however, it does become socially feasible when combined with the preferences of the other age group. Another difference between the generations is that the interviewees in the 16-30 group graded all solutions relatively close to each other, whilst the 60+ group allocated very varying grades. The cause of these differences is not clear as both groups provided roughly the same arguments. It is thus likely that citizens held different weights to different aspects.

The final conceptual framework for social feasibility can be seen in the figure below. It shows that the social feasibility of the solution directions to sea level rise is directly influenced by the perception of climate change and sea level rise, the perceived effectiveness of the measure and the perceived distribution of benefits and costs. These factors are in turn influenced by indirect effects.



Framework to assess the social feasibility of mitigation measures for sea level rise

The perception of the problem was highly present amongst the interviewees as all interviewees agreed that sea level rise is a serious issue requiring a solution. The opinions on the effectiveness of the solution directions varied, indicating a need for further research to provide clearer data to the public. Nevertheless, the opinion of the effectiveness aligned with the overall preference for the solution directions. Additional research is also needed to create a clearer picture of the benefits and costs of the solutions. Despite the lack of information, the interviewees were able to form an opinion based on the aspects they found important. Many aspects were naturally named by multiple interviewees (see the Framework). Although opinions on these aspects differed, the perceived distribution of benefits and costs was similar to the overall preference for a solution.

The research also had some interesting findings related to the indirect influences. Firstly, the previous knowledge of interviewees played a substantial role in how a solution was perceived. The previous knowledge that interviewees had varied and ranged from basic knowledge about dikes to in-depth knowledge of a solution direction. Secondly, the way a solution measure was explained (suggested mitigation measures sea level rise) influenced the opinions of citizens, this was mainly seen through the influence of the visualisations of the solution directions and by the fact that the combination of the directions was explained in more detail than the others.

This thesis contributed to the academic literature by filling part of the knowledge gap on the opinions of citizens on drastic future measures against sea level rise. It also provides insight into how different generations perceive climate change as it found that little difference exists and both age groups feel the seriousness of the issue and see a need for a solution. Finally, this thesis showed that the framework of Feitelson and Salomon is not enough to assess the social feasibility of potential solutions to sea level rise. To overcome this knowledge gap, the framework shown above that can be used to assess the social feasibility of a mitigation measure for sea level rise was created.

From a societal perspective, this thesis has two implications. Firstly, the conceptual framework for social feasibility can be used to assess if a technology is socially feasible which is useful to mitigate potential social backlash. Secondly, the findings of the social feasibility of the solution directions for

sea level rise can guide policymakers in creating an effective and balanced solution. This thesis shows that the final solution should be a combination of solution directions, prioritizing effectiveness and achieving a positive balance of the benefits and costs shown in the framework.

Finally, several limitations and ideas for future research are identified. Firstly, the findings of this research cannot be generalised due to the limited number and limited diversity of interviewees. Future research should include a larger and more diverse sample to make the findings generalisable. Secondly, more research is needed on the technical details of the solution directions so citizens can better understand the effectiveness and impacts. Additionally, an assessment of why the combination was assessed as the best solution to sea level rise is needed. This also includes an assessment of the preference for this specific combination or a different combination of the solution directions. Finally, future research on the conceptual framework for social feasibility is needed to see if it is the same for different population groups and if it is applicable to different technologies.

Inhoud

1. Introduction

According to multiple scientists (Bars et al., 2017; Drijfhout & Le Bars, 2021; Haasnoot et al., 2018) it is certain that the sea level is rising and will keep rising, but the extent to and speed at which this happens is uncertain. Sea level rise depends on the amount of greenhouse gasses the world emits. If emissions can be reduced, the global sea level will increase by 1 meter between 2150 and 2350 (Drijfhout & Le Bars, 2021). If we do not reduce emissions, this will happen between 2090 and 2140. However, there are also events such as the collapse of ice cliffs which could cause the 1-meter increase to already be reached by 2070 and a 2-meter increase by 2090 (Drijfhout & Le Bars, 2021). As the Southwest Delta of the Netherlands already lies beneath the current sea level, there is a huge challenge for the area to remain dry.

In the Southwest Delta of the Netherlands, water and flood risk management are thus of great importance (van der Wekken et al., 2022). Within this area, the densely populated city of Rotterdam lies. Here there are many different interests in water management which can sometimes be conflicting. There is, for example, a need for housing, cultural landscapes, nature areas and also the port area of Rotterdam. Each of these aspects has different preferences regarding water management which makes it a complex challenge to design a solution.

In the coming decades, the water system in this area needs to be adapted to accommodate the rising sea level. As these extreme high water levels have not been dealt with before, innovative technologies or old technologies on a larger scale than ever before must be used. Technologically speaking there are many possibilities. Deltares (Haasnoot et al., 2019) has assessed that possible solutions can be classified into four categories: 1) protect-closed, which means that the coast will be protected through hard or soft measures and rivers would be closed; 2) protect-open, same as protect-closed, only the rivers would remain open to the sea; 3) seaward, the creation of new, higher and seaward land; 4) move along, reduce vulnerability by heightening land, different spatial planning or migration (Haasnoot et al., 2019). These categories can also be combined. Each of these categories has different positive and negative effects. An explanation of these measures can be seen in Appendix 1.

Research on the societal aspects of climate adaptation policies has found that for effective implementation of technical solutions, not only the technical aspects but also political and societal aspects have to be assessed (Drolet, 2021; Hossen et al., 2022). As new (forms of current) technologies are necessary, the framework of Feitelson and Salomon (2004) can be used. They suggest that unless an innovation is technically, economically, socially and politically feasible, it will not be adopted. As the adaptation of the Dutch Delta to sea level rise is a big task with many implications in all these aspects, it is necessary to research the feasibility of these aspects.

From the technical side, a lot of research has been conducted and much is possible[1]. The economic aspect is largely related to the political feasibility as such large infrastructural projects will be funded by the government. The political feasibility is closely linked to the social feasibility as politicians are likely to follow the wants of citizens as these citizens decide if they will be re-elected. The social feasibility is thus a good place to start researching the likely feasibility of solution directions for sea

[1] Mentioned by experts in the fields Jos Timmermans (researcher in the field of adaptive delta management), Tom van der Wekken (retired project manager Rijkswaterstaat) and Erik van Berchum (Consultant Hydraulic Engineering and Flood Risk Management at Arcadis). Corroborated when searching sites of the Deltaprogramme (https://www.deltaprogramma.nl/), Knowledge Programme Sea Level Rise (https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/maatregelen-om-overstromingen-te-voorkomen/kennisprogramma-zeespiegelstijging) and Deltafacts (https://www.stowa.nl/deltafacts).

level rise. From the literature review (see Chapter 3) it becomes clear that the social feasibility of solutions for sea level rise has not yet been researched.

Decisions relating to climate change have a large moral aspect as they require us to make judgements about values and the desired state of the present and the future world (Lau et al., 2021). The morals of people thus play a role in decision-making related to climate change. According to Lau et al. (2021), there are two moral dimensions to climate change decisions. First, there are dilemmas about the burdens of responsibility and the uneven climate impacts on current and future generations. This is because the problems, solutions, costs and benefits extend over a long time frame (Frumkin et al., 2012). Secondly, moral worldviews can shape the context, character and limits of decision-making itself. This research mainly focuses on the second dimension as it aims to assess if and to which degree the solution directions are socially feasible which is based on the moral view of citizens. To also partly take the first dimension into account, it will be reviewed if there is an intergenerational difference in the moral worldview regarding climate change decisions.

The aim of this MSc Thesis is thus to assess the social feasibility of the solution directions to sea level rise formulated by Deltares (Haasnoot et al., 2019) amongst different generations in the municipality of Rotterdam. This leads to the following research question: *"What is the social feasibility of the solution directions for sea level rise amongst different generations in the municipality of Rotterdam?".* This is answered through the following steps: [S1] conceptualizing social feasibility through literature research, [2] assessing the opinions of citizens of different generations in Rotterdam on the solution directions through interviews, and [S3] assessing the implications of the findings through literature research. The combination of literature research and interviews has been chosen as this provides both an analytical perspective and a closer look at the personal opinions of citizens. This report first shows the methods that were used to conduct the research. Then a literature review including the knowledge gap is shown. After which each subquestion is answered. Finally, the discussion and conclusion are provided.

2. Methods

This section shows the methods used to conduct the research.

2.1 Research design

A qualitative research method was used, namely a combination of literature research and interviews. This was chosen as the research is explorative and little previous knowledge is available. Qualitative research fits this thesis as it is a means to explore and understand the meaning individuals or groups ascribe to a social or human problem (Creswell, 2009). Qualitative researchers seek to understand the context or setting of the participants (Creswell, 2009). The process of qualitative research is largely inductive which means that meaning is generated from data collected in the field. The data analysis builds from particulars to general themes, and the researcher makes interpretations of the meaning of the data (Creswell, 2009). It can thus be used to identify the opinion of citizens and to get an understanding of their arguments. This research method makes it possible to go more in-depth on the arguments of citizens than quantitative research would.

The set-up of the research design was done in multiple steps. First, the existing literature on the solution directions to sea level rise, the social feasibility of these solution directions and the intergenerational aspect of climate change have been researched. This led to the assessment of the knowledge gap (section 3.4). Then the following subquestions were assessed.

- [S1] How can social feasibility be conceptualized for the solution directions for sea level rise from Deltares?
- [S2] What is the social feasibility of the solution directions for sea level rise amongst citizens of different generations in Rotterdam?
- [S3] What are the academic and social implications of the findings of the social feasibility of solution directions for sea level rise amongst citizens in Rotterdam?

To answer the main research question, first social feasibility has been conceptualised through literature analysis. Secondly, the social feasibility has been researched through interviews with citizens in Rotterdam. This has been assessed according to the framework that was created in S1. After which the implications for academics and society have been assessed. This also includes adaptations to the conceptualisation of social feasibility that has been made in S1. These adaptations were made using the findings from the interviews [S2].

2.2 Data collection

The data was collected through literature research and interviews. The literature review (Chapter 3) has been done through literature research. Subquestion 1 has been answered through literature research. Subquestion 2 used interviews with citizens of Rotterdam. Subquestion 3 combined previous findings that are shown in this thesis to assess the implications.

2.2.1 Literature research

The literature research has been used to conduct the literature review and to answer the first subquestion. It thus has two functions: to gather background information and to create a conceptual model for social feasibility.

The literature used for the literature review and the creation of the knowledge gap in Chapter 3 was collected in two different ways. For the first part (section 3.1), the finding of basic information about sea level rise and the solution directions, most data was from two sources: Haasnoot et al. (2019) and KNMI (n.d.). It was chosen to mainly focus on these sources as the document from Haasnoot et al. describes the solution directions to sea level rise and provides a clear overview. The findings from this

report were corroborated by other documents (see Appendix 1). The source of KNMI was used to show the degree of sea level rise that is expected to occur. As the KNMI is the Royal Dutch meteorological institute, and as the data was supplemented with other sources, this was deemed sufficient and no full literature review was undertaken. The solution directions from Deltares (Haasnoot et al., 2019) were chosen as the main focus of this research as they provide a good overview of the possible measures to protect the Netherlands from sea level rise. Furthermore, visualisations of the directions have been made which make it easy for interviewees to understand what each direction entails. The final reason for choosing the solution directions is because of the trade-offs that have to be made when choosing between them. Each solution direction has different impacts on aspects such as nature, available land and financial costs. It is not possible to have one solution which is perfect in every way and therefore a trade-off will always have to be made. It is interesting how different people make this trade-off and decide which solution direction they prefer. A combination of the solution directions is also researched as it is likely that in reality a combination will be made.

The second part was the assessment of the social feasibility of solution directions for sea level rise (section 3.2) and the assessment of the intergenerational aspects of climate change (section 3.3), this was done through the assessment of numerous sources on ScienceDirect and Scopus. These sites were chosen as they include many academic papers and they have many search options which makes finding documents easier. One part of assessing the social feasibility of solution directions was to assess the attitudes to adaptation measures for sea level rise. The search method for this literature review can be seen in Figure 1. It was chosen to only focus on literature about Delta regions as these regions have specific properties. The most important property is that citizens often have direct experience with flooding or know stories of flooding in the region and thus already know about the dangers of floods and the potential risks of sea level rise. Delta regions anywhere in the world have been assessed, no more specific geographic region has been chosen as little literature was available.

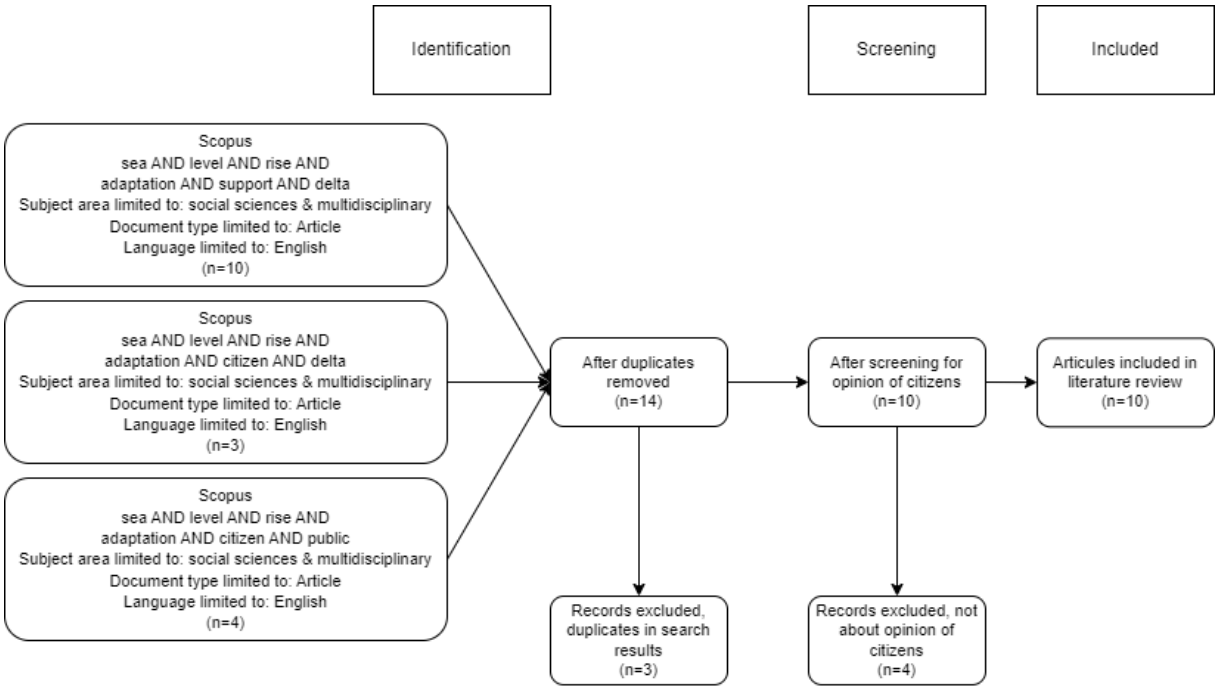


Figure 1: Method literature review attitudes to adaptation measures

The literature research for the first subquestion aimed to assess how social feasibility could be conceptualised. First, it was assessed which frameworks already existed that conceptualised social feasibility (section 4.1). The reason for this was that if a fitting framework already existed, this could be used as the basis of this thesis and this thesis could built upon that framework. This was done

through a general search on Google Scholar with the terms *conceptualisation "social feasibility"* and *conceptualisation "social acceptance"*. Social acceptance was included alongside social feasibility as these terms are often used interchangeably. The results of these terms were assessed until no more relevant results were found, this occurred after a couple of pages. No more specific search strategy was used as this could lead to the exclusion of potentially relevant documents with interesting frameworks. The chosen framework (section 4.2) was combined with findings from the literature review (sections 3.2 and 3.3) to create the adapted framework to assess the social feasibility of the solution directions to sea level rise (section 4.3). This way a fitting framework for this thesis was created.

2.2.2 Interviews

The interviews were held with citizens of Rotterdam or people who lived close to Rotterdam and had a strong connection with the city (e.g. through work, school or social events). This region was chosen as there are many different interests in this region - e.g. water safety, housing, nature, industry - which creates interesting trade-offs. Furthermore, a specific visualisation for a combination of solution directions for sea level rise in the city of Rotterdam has been found (Figure 8). This visualisation helped interviewees to get a sense of the impacts of the measures and made it less abstract.

As mentioned in the literature review (section 3.3), the differences in opinions between generations are interesting to assess. Different opinions have been found in literature (Section 3.3). Firstly, some say that it is likely that older people will feel a lesser need for mitigation measures as they will not experience the measures in use, whilst younger people are likely to have a higher need for measures as they will live for a long time and thus experience the sea level rise. Other literature shows that older people experienced more events of flooding and have a sense of legacy which causes them to have a higher sense of urgency than young people. As there is no consensus, it is interesting to assess the potential difference in attitudes between different age groups.

Two different age groups have been interviewed, namely people between 16 and 30 years and people older than 60 years. The minimum age has been decided as this is the minimum legal age for consent. The group of 16-30 years falls mainly in Generation Z (born between 1995 and 2012) and also includes some of the young Millennials (Robinson, 2017). The 60+ group mainly falls in the baby boomers (1946-1964) and also includes some people of the silent generation (1925-1945) (Robinson, 2017). These age groups have been chosen as they exclude the middle generation (generation X). The middle generation is not researched as this would likely lead to overlaps in attitudes and is therefore less interesting.

As the research was explorative and it was difficult to assess how many interviews were needed, the aim was to reach a saturation point for each age group. This saturation has been reached as no new arguments were introduced in the last interviews. Figure 2 shows the interview methodology. This will be further explained in this chapter.

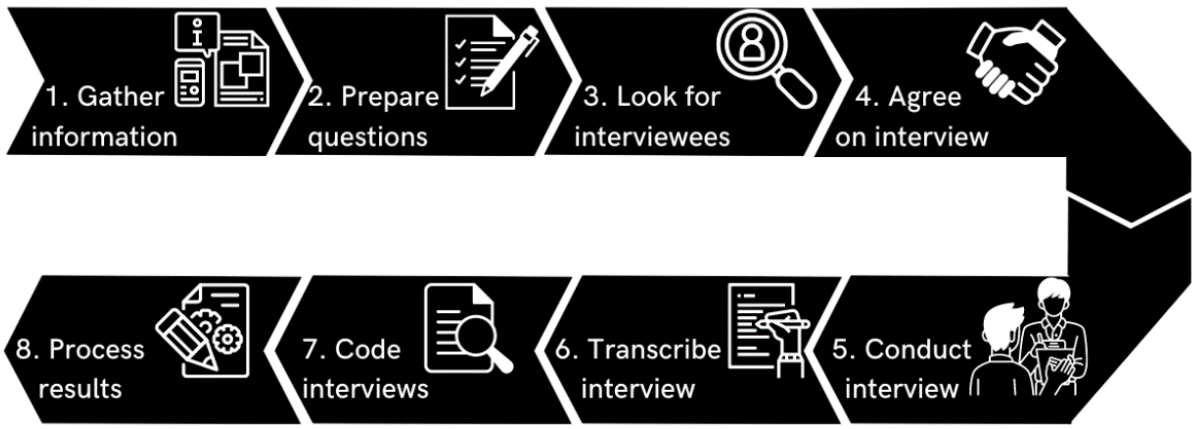


Figure 2 Interview methodology

Step 1 entails the gathering of information that is necessary to conduct the interviews. This is the literature research that has been described earlier that is needed for the literature review and the conceptualisation [S1].

Step 2 is the preparation of the questions for the interviews. The interviews were semi-structured, which means that some structure is followed, but there is room to deviate from this structure. This has been chosen as it can be ensured that no important questions were forgotten in the interviews while there was still room to ask more about a certain topic. The structure that was followed is based on the conceptualisation of social feasibility that was made in S1 (see section 4). At the start of each interview, the consent papers (Appendix 3) have been read and signed by the participants. This ensured that the interviewees were aware of the research process and their rights. The second part of the interview consisted of questions related to sea level rise in general. The third part focused on the solution directions. The separate solution directions were discussed one by one in differing orders for the interviewees so there were no order effects in the results. After all solution directions were discussed, the combination of directions was discussed. The discussion of the solution directions and combination had the same strategy; namely, first, the solution was explained after which questions related to the conceptual framework (see section 4.3) were asked. The fourth and fifth parts contained some questions related to the indirect influences in the framework. The fifth part included some more sensitive questions about the personal life of the interviewee. As these questions are quite sensitive, it was emphasized that participants did not have to answer these questions if they felt uncomfortable with them. It was also mentioned that this will not compromise the rest of the interview as these questions were only used to get an understanding of the representation of citizens.

The specific interview questions are shown in Appendix 2. The order in which the solution directions were presented was alternated between participants to ensure that it was not the case that one solution direction would be seen as the best because it was the first or the last that was presented. This was thus done to reduce the order effects.

Step 3 is searching for participants. In an attempt to find diverse participants, multiple places were emailed and called. Examples are, political parties for young people (e.g. Jong Rotterdam), neighbourhood associations, elderly organisations, and meeting places in neighbourhoods. These attempts were futile as they led to no responses or problems with privacy regulations. This meant that all participants in the study were found through my own network and through snowballing (asking participants if they know other people who would be willing to participate).

In total 8 people were interviewed from the 16-30 group and 8 from the 60+ group. In each group, one person was lower educated, one person had done or currently did HBO and the rest had or currently followed a university education. The ages ranged between 21-29 and 60-85. In the young group the number of men and women was equal, in the elderly group there were 3 men and 5 women.

The next step was 4) agreeing on an interview with the participant. This included the practical aspects of a time and a location. The fifth step was the actual conducting of the interview. Steps 6, 7 and 8 are explained in the data analysis section.

2.3 Data analysis

Step 6 is the transcribing of the interviews. The audio of the interviews was recorded which made it possible to transcribe them. The transcribing was initially done with the transcribe function in MS Word, this programme is useful as it transcribes audio quickly; however, it does make quite a few mistakes which required the transcription to be checked. After the automatic transcribing by MS Word, each interview was thus relistened to and corrected. It was chosen to transcribe the interviews so no arguments would be missed and the data was thus complete.

Step 7 is the coding of the interview. This has been done in Atlas.ti. The first step was to open code the interviews. This means that each transcription was read and labels (codes) were assigned to text fragments that were deemed important (Dingemanse, 2021). It was aimed to give similar text fragments in different interviews the same code so it was easier to process. At the same time part of the next step, axial coding, was done. Axial coding means that it is checked if codes belong to an overarching theme (Dingemanse, 2021). An example of how this was done for this research is that codes that belonged to one of the solution directions were already grouped together. After all interviews were coded, the codes were checked and codes that were very similar were combined.

Finally, step 8 the processing of results was done by assessing each code in Atlas.ti and writing the result section on this. This was done per combination and per aspect. When a code was included in the results it was highlighted so it could be checked at the end if all codes were analysed and nothing was missed. This way it was ensured that all arguments were included in the results.

3. Literature review

This section provides the literary background needed before the research could start; part of this literature research is also used to create the conceptual framework for social feasibility (Chapter 4). First, some general information about sea level rise is explained. Then a summary of the solution directions to sea level rise and a combination of these directions is provided. Then it is assessed how much information is already available about the social feasibility of the solution directions against sea level rise. As no direct information about this is available, this is done in multiple steps by starting broadly and narrowing down towards more specific literature. This literature review leads to a knowledge gap (3.4) which will be aimed to be solved in this paper.

3.1 Information sea level rise and solution directions

First some general information on sea level rise in the Netherlands is explained; after which, the solution directions that are the focus of this research are explained.

3.1.1 Amount of sea level rise

Figure 3 shows the estimated sea level rise until 2100 by the KNMI. The red, purple and green lines are sea level rise scenarios for the Dutch coast around 2050 and 2100. In these scenarios, subsidence is included and they are calculated compared to the NAP. The red line shows the high emission scenario (SSP5 8.5-scenario) where emissions will keep rising till 2090. Purple shows a moderate emission scenario (SSPS2 4.5-scenario) in which emissions will increase until 2050 and then decrease. Green shows a low emission scenario (SSP1 2.6-scenario) where the emissions will decrease in 2020 and become negative after 2070 (Paris Agreement). The light-coloured bands around the lines show the uncertainties. These show that the highest scenario is a sea level rise of 1.25m in 2100 and the lowest is 34cm. (KNMI, n.d.)

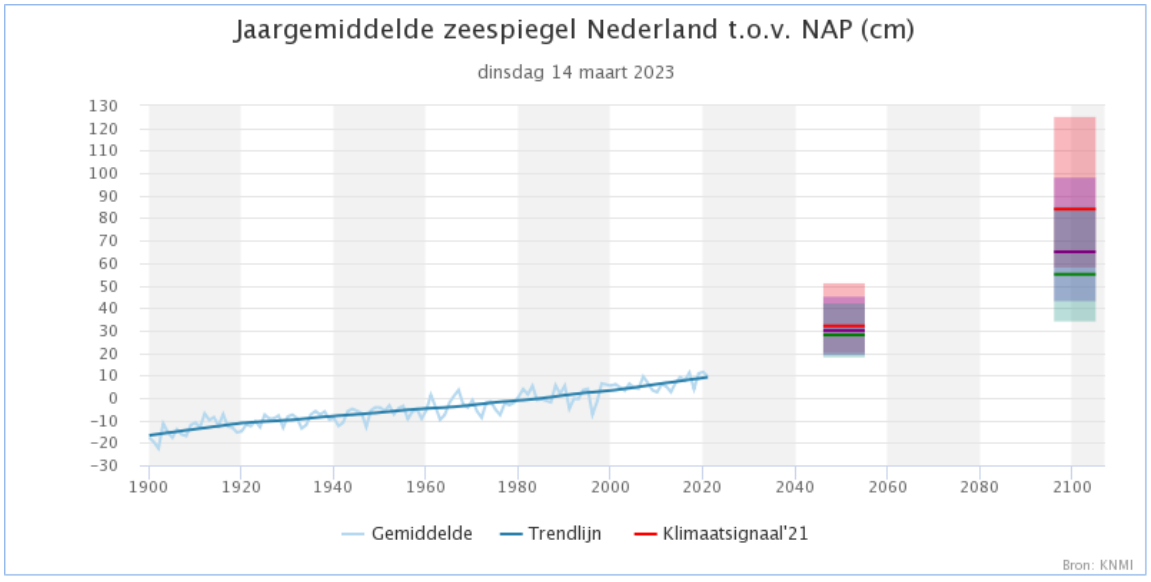


Figure 3 Sea level rise Netherlands compared to NAP (cm) (KNMI, n.d.)(see text above for explanation colours)

Other research suggests that the break-up of Antarctic ice shelves could cause the sea level to rise even more (Bars et al., 2017). They show that the sea level could rise by up to 292 cm by 2100 if they take the highest published projection of mass loss from Antarctica (Bars et al., 2017). The sea level is likely to keep rising after 2100 and can potentially rise to 5-8m in 2200 (Haasnoot et al., 2018).

A consequence of sea level rise is that storm surge barriers need to close more often and eventually need to close for good. Furthermore, during big storms, more water will go over the barriers more often. Another consequence is that more sand is needed to uphold the coastline; around 2050 this will

be three to four times as much compared to now, in 2100 this can increase up to 20 times as much as now. Sea level rise will also lead to a stark increase in salt intrusion through the rivers. To stop this, inlet points of rivers would need to be closed more often. Salt intrusion will also occur through groundwater which will lead to problems with agriculture. (Haasnoot et al., 2018)

3.1.2 Solution directions

Deltares (Haasnoot et al., 2019) has classified possible solutions to sea level rise for the Dutch Delta into four categories. This thesis focuses on quite extreme levels of sea level rise which causes one of the solution directions, protect-open, to not be possible and it has thus been decided to combine this direction with protect-closed as these are quite similar and protect-open will result in protect-close with higher sea levels. This section provides a summary of these categories. Furthermore, a short explanation of a plan for the combination of these measures in Rotterdam is shown. A more in-depth explanation can be seen in Appendix 1. Each solution direction has a visualisation which is an extreme depiction of the measures. Finally, the key differences will be explained.

Protect

This combined solution direction entails protecting the current land from sea level rise. This can be done through measures such as dikes, dunes and storm surge barriers. In the protect-open scenario, the rivers (Meuse and Rhine) are in open connection with the sea and will be closed by storm surge barriers when there are high sea levels. At around 1.5m it is not feasible to open these barriers and you automatically go to the protect-closed direction in which the rivers are closed-off from the sea.

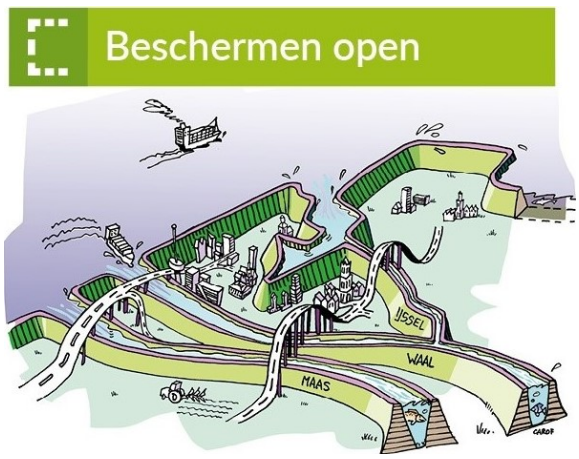


Figure 4 Protect-open

Figure 5 Protect-closed

Seaward

Seaward means that new, higher, seaward land will be created to protect the land from flooding. This land can be attached to the current land or be separated in the form of islands. This new land can also be used for other things than flood defence such as housing, nature, recreation or industry.

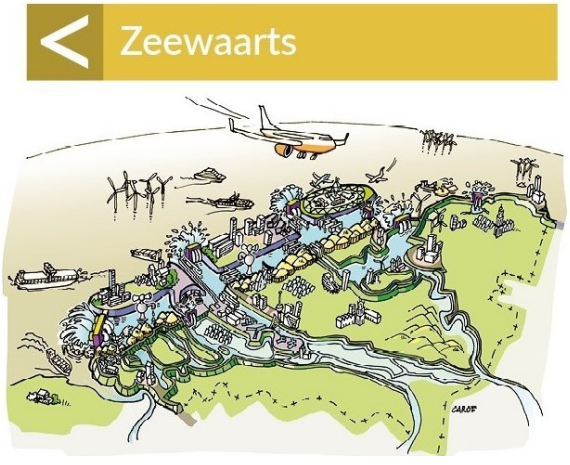


Figure 6 Seaward

Move along

Move along with the water entails that you reduce the vulnerability of the country by heightening land, different spatial planning or migration. This direction includes measures such as building houses on poles or mounds, creating floating buildings and migrating to higher areas.

Figure 7 Move along

Combination of solution directions

It is not necessary that only one of the solution directions is chosen but it is also possible that they will be combined. Figure 8 shows a vision of how this could be done in the area around Rotterdam for 2-3 m of sea level rise. For the seaward direction (yellow areas), there will be extra land attached to the coast and small islands near the coast which will act as breakwaters. The protect direction is included by closing off the city centre from tides with sluices (2) and by creating more and higher dikes (1). The move along direction is included by creating more space for water in the Biesbosch (4), creating peat marchlands where water can be stored (9), and by creating a controllable overflow area (10). (De Urbanisten, LOLA (LOst LAndscapes), & Royal Haskoning DHV, 2022)

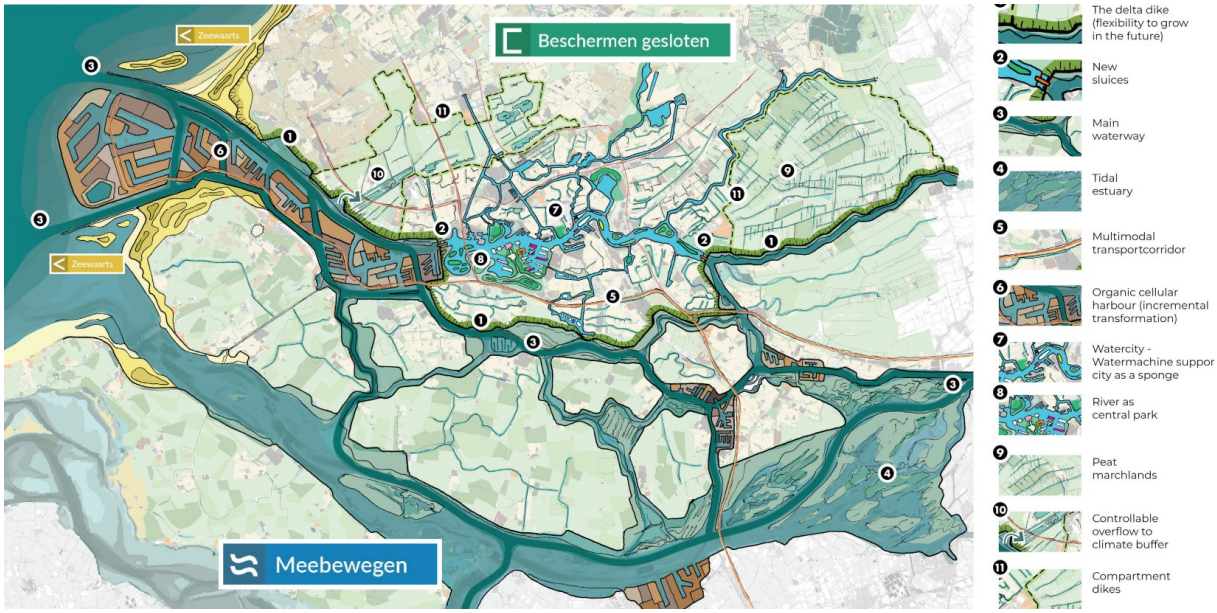


Figure 8 Combination of the solution directions

Key differences

Even though each solution direction has the main goal to keep the Netherlands save from sea level rise, there are some big difference. The key difference is that the protect direction is about safeguarding existing land, while seaward is about creating more land and move along is about giving away land and making more room for the water. This key difference leads to many different impacts in different aspects, for example, the technical difficulty of the required measures, the reduced or increased liveable space and the impacts on nature. It is impossible to have a solution which satisfies

all wishes and there are thus interesting trade-offs to be made when choosing between the solution directions.

The combination aims to provide a balance in the trade-offs and is therefore more balanced. It is also explained more in-depth and precise than the separate solution directions. It is interesting to also provide this combination to interviewees as it is less extreme than the separate solution directions. As this combination is very different to the separate directions, it was included in the interviews as the last potential solution after the other solution directions. This way the interviewees first had to consider the trade-offs between the separate solution directions before they saw the possibility of combining them.

3.2 Literature review on social feasibility solutions sea level rise

This section shows the information that is already available about the social feasibility of the solution directions against sea level rise. As no direct information about the solution directions is available, this literature review is done in multiple steps. First, it was assessed what literature says on attitudes to climate change and sea level rise in general (3.2.1). Then, literature on attitudes towards climate policies is assessed (3.2.2). Finally, literature on attitudes towards adaptation measures to sea level rise in Delta areas is assessed (3.2.3). The literature review thus starts broad and narrows more towards specific measures. Note: the literature review mainly assesses literature on attitudes of citizens as there is little literature that directly discusses the social feasibility of solutions to sea level rise.

These findings are also used in the creation of the conceptualisation of social feasibility (Chapter 4). Aspects which are found to be of importance for the social feasibility of solutions to sea level rise in this chapter are combined with the existing framework of Feitelson and Salomon to create a specific conceptualisation which fits this thesis.

3.2.1 Attitudes to climate change and sea level rise

A survey with 40,000 respondents across twenty high-emitting countries has found that the majority of people realize that climate change is real and human-caused (Dechezleprêtre et al., 2022). Most respondents also accurately understand some consequences of unabated climate change such as sea level rise, droughts, and heatwaves. However, people also have difficulty distinguishing between different types of disasters. For example, most also believe that climate change will entail more frequent volcanic eruptions. This study also found that respondents disagree about which measures should be taken to fight climate change.

In a study (Buckley et al., 2017) about the opinions of Europeans on climate change in marine environments, it was found that 43% of citizens felt informed about the topic of sea level rise. 70% felt concerned about sea level rise, this was relatively high compared to other topics related to climate change. The researchers also tested how well citizens could estimate the amount of sea level rise. 40% of respondents estimated that the sea-level would rise by 10cm to 1m over the next 100 years, and 27% said that it would be between 1 and 5m. As there are some uncertainties in sea level projections, these estimations are both correct and thus roughly two-thirds of the estimations of respondents match well with expert opinion.

The Red Cross (Het Nederlandse Rode Kruis, 2023) conducted a survey on floods in the Netherlands. It shows that over 80% of the respondents are not really or not at all prepared for a flood. Only 4% think the chance is high that their home will be partly underwater in the coming ten years. Whilst almost 1 in 4 respondents have had to deal with or know someone who had to deal with big flooding. This thus shows that Dutch citizens are not well prepared for a flood and also do not consider it a big risk.

3.2.2 Attitudes to climate policies

Dechezleprêtre et al. (2022) found three main factors that influence the support for a climate policy: 1) the perceived effectiveness of a policy, people will be more supportive of a policy if they believe, for example, that a policy helps reduce emissions. 2) inequality concerns, a policy should not have adverse distributional impacts by hurting lower-income households. 3) self-interest, the policy should not (financially) hurt the participant. Furthermore, they found that an explanation of the effectiveness and implications of a policy increases the support; this explanation included how the policies work and whom they impact.

Some articles also mention personal and social factors that influence the attitudes of citizens toward climate-related policies. Dechezleprêtre et al. (2022) found that left-wing and college-educated respondents are more supportive of climate action. Kulin, Seva & Dunlap (2021) found that people with a nationalist ideology who belong to right-wing parties are more likely to be sceptical about the realities of climate change, and substantially more likely to oppose increasing taxes on fossil fuels. Poortinga et al. (2019) see that men, older age groups, and those with fewer years of formal education tend to be more doubtful about the reality and human influence of climate change.

3.2.3 Attitudes to adaptation measures to sea level rise in Delta regions

A scientific literature review was undertaken to assess previous literature on citizens' opinions on adaptation measures to manage sea level rise in Delta regions. Table 1 shows the articles that were found, what they explain, the geographical area that the research took place in and finally, there is a column for notes if something stood out.

Table 1: Summary of articles

Source	Assesses citizens opinion	Assesses adaptation citizens made	Finds barriers/ opportunities for adoption	Explains way to inform/ convince citizens	Explains decision-making factors	Geographic area	Note
Mills et al., 2022		x	x			Mekong River Delta - Vietnam	Focuses on salinity in rice production
Oukes et al., 2022			x			Dordrecht & IJssel-Vecht Delta – Netherlands	
Paik et al., 2020		x	x			Mekong River Delta - Vietnam	Focuses on adoption of salt-tolerant rice varieties
Lokman, 2019				x		Fraser River Delta - Canada	About using visualizations for communication
Warner & Boas, 2017				x		UK and Netherlands	About effects of securitisation
Barron et al., 2012			x	x		British Columbia - Canada	
Teodoro et al., 2020					x	Netherlands	About intergenerational justice
Verduijn, Meijerink				x		Netherlands	Assessment of success of Second Delta Committee

& Leroy, 2012							
Aragón-Duran et al., 2020			x	x	x	Carahatas - Cuba	Assesses understanding of locals on sea level rise policy
Burby & Nelson, 1991			x			USA	

The aim was to find the opinion of citizens on adaptation measures for sea level rise, as can be seen in the first column of Table 1, this has not directly been found; however, other aspects that relate to this have been found. It is important to assess if the combination of the different articles answers all questions or if a knowledge gap remains; therefore, the main findings are discussed below.

Adaptations made by citizens

Mills et al. (2022) and Paik et al. (2020) assessed the uptake of salinity-tolerant rice varieties. They found that the adoption of measures is quite high. It is relatively higher when farmers experienced the negative effects that the measures try to prevent. In the case of the uptake of salinity-tolerant rice varieties, the uptake was higher when farmers experienced higher salinity in the ground.

Barriers for adaptation

The barriers to adaptation described in the literature can be classified into three categories.

Communicational/educational barriers

Aragón-Duran et al. (2020) found that in Cuba there is a gap between how academics/decision-makers and local residents understand risks related to climate change. This causes the needs of local residents to be overlooked. This is partly corroborated by Oukes et al. (2022) as they find that false, low or non-existent safety perception and risk awareness are barriers. These aspects often occur because of a lack of information in either direction. Burby and Nelson (1991) also assess that the main obstacles exist in a lack of information about the risk, the adjustments and the cost-effectiveness of alternatives. Furthermore, Oukes et al. (2022) find that suboptimal collaboration between stakeholders and ambiguity and uncertainty regarding responsibilities are barriers.

Economic barriers

Mills et al. (2022) found that fear of lower rice production and a lack of clear economic benefits hinder adoption. This was supported by Oukes et al. (2022) as they found that finance and (temporal) cost-benefit imbalance could be a barrier. Oukes et al. (2022) also mentioned a lack of human capital as a barrier.

Physical-spatial barriers

Deep maximum flood depths, a lack of space, and rigidity of the existing built environment can be a barrier (Oukes et al., 2022). This is the case in Deltaic and coastal areas as these are often densely populated and urbanized.

Opportunities for adaptation

The main opportunities for increasing the adoption of measures against sea level rise are found in improving communication and education (Paik et al., 2020; Oukes et al., 2022; Aragón-Duran et al.,

2020). Information spillovers from neighbours can also increase adoption (Paik et al., 2020). Economic opportunities also lead to faster and more adoption of measures (Mills et al., 2022).

Ways to inform/convince citizens

Different methods to inform and convince citizens of the need for adaptations to sea level rise were found. Lokman (2019) argues that visualisations help to show the impacts of sea level rise and to promote new ways of seeing the Delta. Verduijn, Meijerink & Leroy (2012) argue that framing strategies such as adherence to the climate adaptation narrative, using the story of our delta identity, creating a sense of urgency and collectiveness, and creating a crisis narrative are helpful. Aragón-Duran et al. (2020) found that understanding the expectations and needs of local residents helps create better policies. Barron et al. (2012) mention that incorporating plans for sea level rise in ongoing activities and operations can advance adoption. Warner and Boas (2017) assess that when framing climate change as a crisis there is a risk of public disengagement and denial of the problem in an attempt to avoid the discomfort of dealing with it.

Aspects that should be taken into account for decision-making

Finally, some other aspects are important during decision-making. The first aspect is intergenerational justice, which means that flexibility ought to be maintained (Teodoro et al., 2020). Commitment from an early stage to one strategy could hinder this. The second aspect is that academics and policymakers should listen to local residents (Aragón-Duran et al., 2020).

3.3 Literature review intergenerational aspects climate change

As mentioned in the introduction, one part of the moral dimension of climate change is the intergenerational aspect of it. This entails that the problems, solutions, costs and benefits of climate change extend over a long time frame, well beyond the lives of those who create or are currently addressing the problem (Frumkin et al., 2012). There are different perspectives on how different generations feel about climate change and there is no clear consensus to this. Therefore, this section provides some of the findings in the literature on this aspect.

There are generally high levels of climate change concern among the younger age groups, in some cases these are higher than in older age groups (Corner et al., 2015). Some people in younger generations are frustrated about the failure of older generations to acknowledge and address threats from climate change (Swim et al., 2022). This can for example be seen in climate protests which were recently often led by young climate activists (Marris, 2019; Sengupta, 2019).

One important aspect of intergenerational frustration is the potential difference in how generations feel about climate change. The American Psychological Association (2018) found that Gen Zs feel more stressed about climate change and global warming than older generations. This is also shown in polling data which indicates that people under 35 are most worried about climate change (Reinhart, 2018). Furthermore, Swim et al. (2022) found that younger generations experience more negative emotions in reference to climate change. Younger generations' worry, anger and guilt about climate change are higher than that of older generations. Additionally, younger generations reported less hope than older generations. However, other research shows that compared to older age groups, young people appear to be less fatalistic about combating climate change and see it as something that could be manageable (Corner et al., 2015).

There are also different views on how older people feel about climate change. In the first view, they might not care as they will be no longer around by the time it has serious effects and they thus may not feel that it will be 'their problem'. One survey shows that older people were less likely to believe

in global warming, that it is a problem or in the anthropogenic role in it (Pew Research Center, 2009). On the other hand, older people might care about climate change. This could be because of three reasons (Frumkin et al., 2012): 1) they are especially vulnerable to some of the impacts of climate change, such as heat waves, diminished air quality, and the disruptions of extreme weather events. 2) when people get older, they may take on political or social views that condition their attitudes toward climate change. 3) older people may feel a sense of legacy, a concern for the well-being of those who will come after them. This is partly corroborated by a survey which showed that people over 60 were slightly more likely than younger respondents to report that they had given a lot of thought to global warming and were worried about it (Feldman et al., 2010). However, at the same time, they were no more likely to believe that global warming is happening or to take action (Feldman et al., 2010).

3.4 Knowledge gap

There is thus a lot of information on barriers and opportunities for the adoption of adaptation measures. Furthermore, there are recommendations on how to inform citizens in the best manner. These aspects can be helpful to increase the adoption or acceptance of measures. What was not found in the scientific literature is the opinion of citizens on drastic future measures. Most of the found scientific literature discusses measures that citizens have the option of using and from which the effects can be seen in a relatively short period.

It was also found that organisations are already working on different possibilities for adaptation to sea level rise. Different solution directions have been created and a potential vision for how this could look for the city of Rotterdam has also been created (Appendix 1). However, the opinions of citizens on these adaptation possibilities could not be found. Even though these measures will have a large impact on the lives of citizens.

Furthermore, it has been found that there is no consensus on a theory for the attitudes towards climate change among different generations. Though consistently we see generational differences in attitudes, emotion, and levels of concern vis-a-vis climate change. Might these differences translate into different attitudes on adaptation solutions? It is interesting to know this as the effects of sea level rise and the chosen solutions will be felt more by young people as they will be alive for longer. It is thus possible that old citizens do not care as much about what is chosen. However, people of all generations can vote for which solution direction they feel is best. Therefore it is relevant to assess if their opinions differ a lot as the social feasibility is determined by the opinions of all generations.

The social feasibility of the solution directions can thus not be estimated yet as the opinions of citizens have not been researched. Therefore, this MSc Thesis aims to solve this knowledge gap by assessing the attitudes of different generations of citizens of Rotterdam on potential adaptation measures against sea level rise. It has been chosen to only focus on the city of Rotterdam as there are a lot of different types of interest already in that area and the entire Southwest Delta of the Netherlands is too large to study in one thesis project.

4. Conceptualisation social feasibility

This chapter answers subquestion 1: *"How can social feasibility be conceptualized for the solution directions for sea level rise?".* First, existing conceptualisations of social feasibility are explained. After which, the chosen basis for the adapted conceptualisation is explained. Finally, the adaptations to this framework are explained.

4.1 Literature review conceptualisations social feasibility

When searching google scholar with the terms: *conceptualisation "social feasibility"* and *conceptualisation "social acceptance"*, and assessing the results, it was found that there were no papers available which conceptualise social feasibility. It was found that most articles (e.g. Cannas, 2012; Hart et al., 2005; Schönauer & Glanz, 2021) assessed social feasibility but did not use a framework for this. There are however some papers which use social feasibility to conceptualise other aspects, for example, Hu et al. (2020) included social feasibility in a conceptual framework for understanding social entrepreneurship opportunities. While others (e.g. Schubert et al., 2015) do use a framework for social feasibility but one which is very much connected to their research subject and therefore difficult to implement on another subject. Devine-Wright et al., 2017 show a holistic approach to social acceptance but this does not show any specific aspects that can influence social acceptance.

As no perfect conceptualisation for social feasibility was found, it was decided to create a conceptual model based on another framework. The framework of Feitelson and Salomon (2004) has been chosen as the basis of this model for three reasons: 1) The researcher is already familiar with this framework; 2) social feasibility plays a large role in this framework; 3) the subject for which the framework was created (assessment of the likelihood that an innovation would be adopted) is similar to the subject of this thesis as this is about the likelihood that a solution direction will be accepted by the public.

4.2 Theoretical framework Feitelson and Salomon

Feitelson and Salomon (2004) have created a framework for analysing the adoption of innovations, see Figure 9. This framework argues that an innovation will be adopted if it is economically, technically, socially and politically feasible. This framework was created for transport innovations, but as there are many similarities between some transport innovations and measures for water safety, it can also be applied here. One aspect in which they are similar is the financial aspect; both large transport innovations (e.g. new/improved rail or road) and protection measures against water are almost always financed and implemented by a governmental organisation. Other similar aspects are that they are both technically complicated, there are often proponents and opponents, and they exist in a complex system with many different interests.

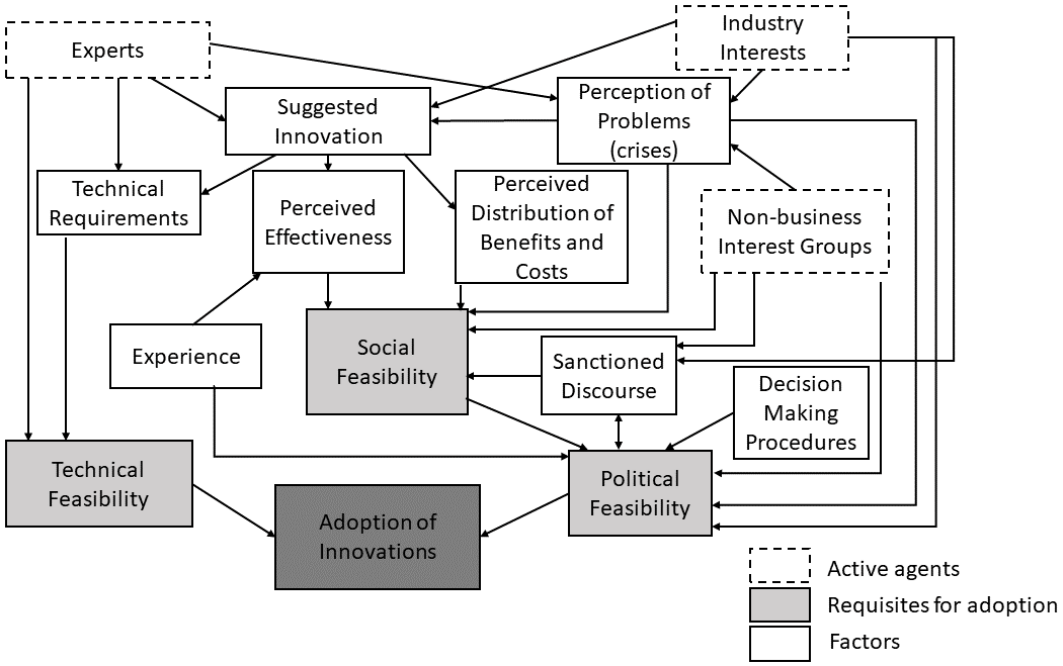


Figure 9 Framework Feitelson and Salomon (Feitelson and Salomon, 2004)

The framework shows that an innovation will be adopted if it is seen as technically, economically, socially and politically feasible. The economical feasibility is included in the social feasibility as when an innovation cannot pass a rudimentary benefit-cost criterion it should be viewed as being unrealistic and thus socially infeasible (Feitelson and Salomon, 2004).

Social feasibility means that the majority of voters are likely to support the innovation. It is dependent on the perceived effectiveness, which is affected by experience with similar policies or systems elsewhere, publications and media appearances. It is also affected by the sanctioned discourse, this is the discourse sanctioned by decision-makers as being politically feasible. All these aspects affect the attitudes that citizens have against an innovation.

The political feasibility is partly determined by the social feasibility as politicians care about voter preferences. However, as citizens do not directly vote for infrastructure projects, the decision-making procedures are also important for the political feasibility. Politicians also take industry interests into account as they also need the support of interest groups to be re-elected.

It is possible that the technical feasibility can be insufficient in practice even though this was previously deemed feasible. This happens when the actual implementation costs become apparent. If the cost proves to be high, it is possible that innovations that were formally accepted by decision-makers will not be implemented, or will be implemented in a minor or highly modified way, as both decision-makers and the technocracy will try to limit their cost.

In the introduction, it is explained that this research will only focus on social feasibility. This is because some research on the technical feasibility has already been done while there is much less research on the social and political feasibility. As social feasibility largely determines political feasibility, because politicians are highly influenced by what citizens think, it has been concluded that the social feasibility is a good starting point to assess the likelihood that certain protection measures against sea level rise will be adopted.

4.3 Adapted framework

The framework of Feitelson and Salomon is combined with findings from the literature that are shown in the literature review (Chapter 3) to create a framework that is useful to assess the social feasibility of adaptation measures to sea level rise.

The framework of Feitelson and Salomon shows that the following factors influence social feasibility (these are the boxes in Figure 9 with the arrows going towards social feasibility): perceived effectiveness, perceived distribution of benefits and costs, perceptions of problems, sanctioned discourse and non-business interest groups. For the adapted framework, the influence of non-business interest groups has been changed to the influence of interest groups in general as all types of groups can influence how people view certain measures. The factors which are influenced by this are broadened so they include all factors that concern how people perceive something. The sanctioned discourse has been relocated to the top as the measures that will be assessed are found in policy documents and are thus part of the sanctioned discourse.

Some of these factors were also found in other literature (see section 3.2), some other factors that are not (directly) included in the framework of Feitelson and Salomon were also found. The first aspect that is found to be influential in the attitudes of people toward climate policies is demographic factors (Dechezleprêtre et al., 2022; Kulin, Seva & Dunlap, 2021; Poortinga et al., 2019). It was found that men, older age groups, people with fewer years of formal education and people that vote for right-wing parties were less likely to support climate change mitigation policies. The second aspect is communication, multiple papers found that a lack of information and/or an unclear explanation of the effectiveness and implications of a policy hinder the adoption (Burby & Nelson, 1991; Dechezleprêtre et al., 2022; Oukes et al., 2022). The communication factor is included in the framework through the suggested innovation as this is how participants will hear about the innovation and will receive an explanation. As this framework is meant for the assessment of the social feasibility of an innovation it is assumed that in all cases, like this thesis, the innovation that is assessed will be explained to the citizens by the researcher. It is also possible that participants have more background knowledge, but this is included in the demographic factors.

Furthermore, two other factors were found but these are not included as they already partly fall under other factors. The first is physical-spatial aspects which fall under the technical requirements in combination with the perceived benefits and costs (as it would cost people if they have to move to accommodate a measure). The second aspect is self-interest which is not included as it is likely that it will come forward in the perceived distribution of benefits and costs if a participant feels that they are hurt by the measure.

This led to the following framework that will be used to assess the social feasibility of different potential measures against sea level rise:

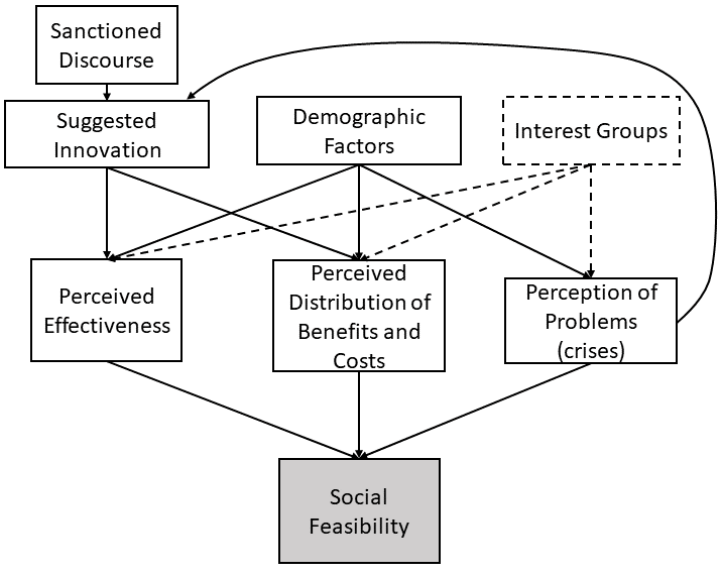


Figure 10 Adapted framework social feasibility

The perceived feasibility that interviewees assess is thus directly affected by the perceived effectiveness, the perceived distribution of benefits and costs and the perception of problems (crises). It is important to realise that it is about how citizens perceive these aspects and not to which state this is true. All interviewees will receive the same basic information about the measures and have their own knowledge to also take into consideration. This can thus lead to one person perceiving that something is effective while someone else perceives it will be ineffective.

Perceived effectiveness entails to which degree people feel that a solution direction will keep them safe. Some of the information that is given by the interviewer on this aspect is to which level of sea level rise the solution direction is likely to help and which measures are included in the solution directions.

The perceived distribution of benefits and costs encompasses everything that people value and find important. It is thus not only about the financial costs but also about things such as environmental and social effects. Ethical concerns, including the distribution of costs and benefits over different generations, are thus also included in this aspect. What people find important differs, some might feel that nature is a very important factor to take into consideration, while others do not. The distribution aspect of the benefits and costs has two different aspects. The first is the distribution between the different types of costs and benefits, e.g. better for the environment versus lower financial costs. The second is the distribution within one type of cost and benefit, this is for example the financial distribution of the costs between people who live in low-lying areas near the coast and people who live in higher areas further land-inwards. This factor thus also includes the ethical aspects of what people feel is a fair distribution. In the interviews, this has not been explicitly mentioned as this could lead to skewed results as people might feel that they have to mention the politically correct answer.

The perception of the problems is the final aspect that directly influences how people view the solution directions. This is the perception that people have of a crisis, in this case climate change and sea level rise. People that do not believe in climate change and do not believe that the sea level will rise, are likely to feel a lesser need to implement one of the solution directions. The perception of the problem

also influences the suggested innovation as the people who came up with the innovation also have a certain perception of sea level rise which causes them to create the suggested innovation.

The indirect factors that influence this are the suggested innovation and the sanctioned discourse surrounding that, the demographic factors and the interest groups. The suggested innovation and the sanctioned discourse are in this case the same for all interviewees as this is the information that the interviewer has provided about the solution directions. As the solution directions are already mentioned in some political reports (see Appendix 1), they are all included in the sanctioned discourse and seen as a potential possibility by politicians (this does not mean that each politician sees each of the solution directions as a good option). Even though there is little urgency to be seen in the sanctioned discourse, there is a general realisation for the need for solutions in the long-term and these are thus included in the sanctioned discourse. Demographic factors can influence the perception of people as people have different backgrounds and diverse previous knowledge. The interest groups influence the perceptions of people as they provide knowledge about sea level rise or a solution direction. Examples of interest groups from which people hear about these topics are television makers, radio hosts, lecturers, etc.

5. Findings social feasibility amongst citizens Rotterdam

This chapter answers subquestion 2: "*What is the social feasibility of the solution directions amongst citizens of different generations in Rotterdam?".* This will be done by assessing each aspect of the framework created in the previous chapter. First, the direct effects will be discussed, after which the indirect effects will be discussed.

5.1 Preference solution directions

5.1.1 General

Each interviewee graded each solution direction and the combination between 1 and 10. Figure 11 shows the average grade per direction. On average, protect received a 7.1; seaward a 6.5; move along a 5.6 and the combination an 8.2. Figure 12 shows the grades per interviewee, most grades are between a 5 and a 9 but there are some outliers. Especially the move along and the seaward solution directions are seen by some interviewees as extremely negative. While the combination is seen as very positive by some.

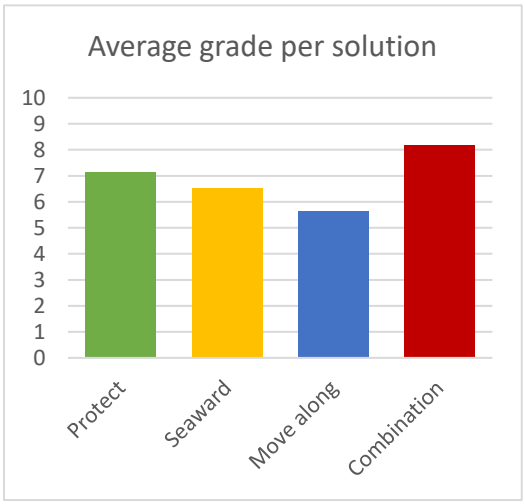


Figure 12 Average grade per solution

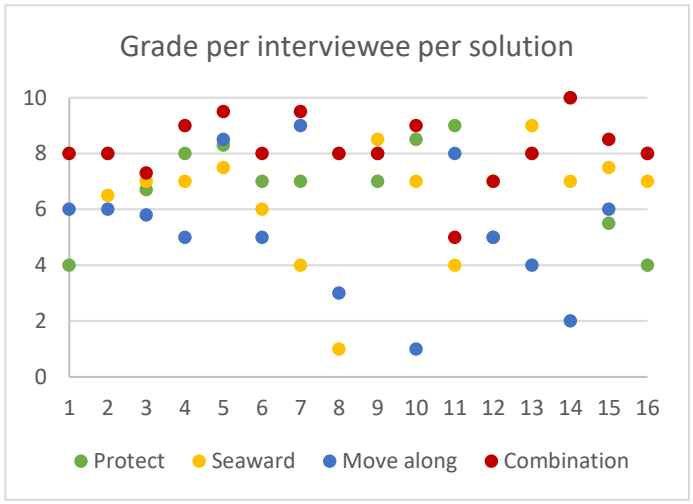


Figure 11 Grade per interviewee per solution

Most interviewees (1, 3, 4, 5, 6, 7, 10, 12, 14, 15, 16) thus believe that a combination of directions is better than focusing solely on one of the solution directions. Interviewees 2 and 8 see either the protect direction or the combination as the best solution. Interviewee 13 believes that we should start with the combination, then move to protect open and to seaward. Interviewee 9 prefers a solution between the combination and seaward direction. Only interviewee 11 does not think that the combination is a good solution, they believe no more investments must be done in low-lying areas and we should be preparing to move towards higher ground.

It was also asked if the interviewees found one of the directions unacceptable. Two interviewees (10 and 13) found move along unacceptable and two (7 and 8) found seaward unacceptable. The other interviewees found everything acceptable or assumed that the government would have such good arguments if a specific direction was chosen that they would find it acceptable.

Even though the combination of the solution directions is preferred, many interviewees mentioned that the distribution amongst the different solution directions might has to change a bit. Interviewees 5, 6, 9, 14, 15, and 16 feel that the combination needs more of the seaward direction. *Interviewee 16: "I think seaward could perhaps be expanded a bit, I think it has been kept fairly small.". Interviewee 15: "But if you take a little more of the seaward, you'll have more land. You can build more, have space for*

more people, get more money out of it.". Interviewee 14 believes that it could also include a bit more of the protect direction so if the sea level rises higher than expected, we are not immediately in danger.

5.1.2 Generational differences

Figure 13 shows the average grades per age group and per solution direction. It can be seen that the average grades for the 16-30 group are more or less the same for each solution direction. The combination does get a higher grade. For the 60+ group, the grades variate much more per solution direction. There is especially a big difference in the move along direction, which is graded very low by the 60+ group. Furthermore, it can be seen that the average grades for the seaward and combination direction are similar between the two age groups; while the average grades differ for the protect and move along direction.

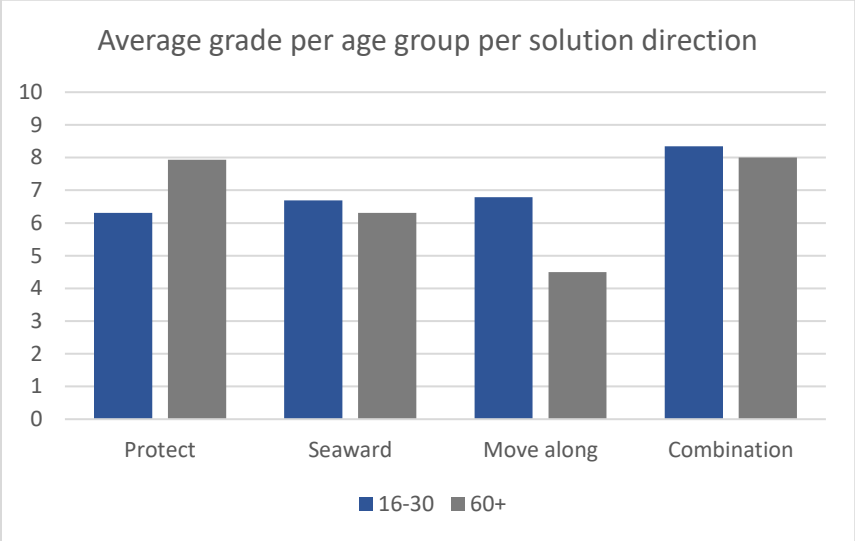


Figure 13 Average grade per age group per solution direction

It is also interesting to see the differences in the spread, which can be seen in Figure 14 and Figure 15. The interviewees in the 30-60 age group graded the directions much closer to each other than the 60+ group which had more extreme grades.

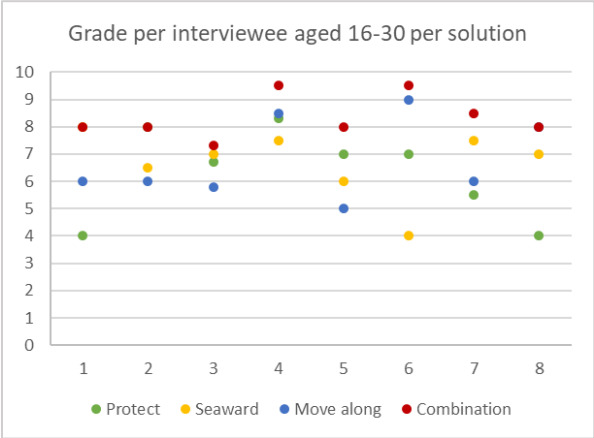


Figure 15 Grade per interviewee aged 16-30 per solution

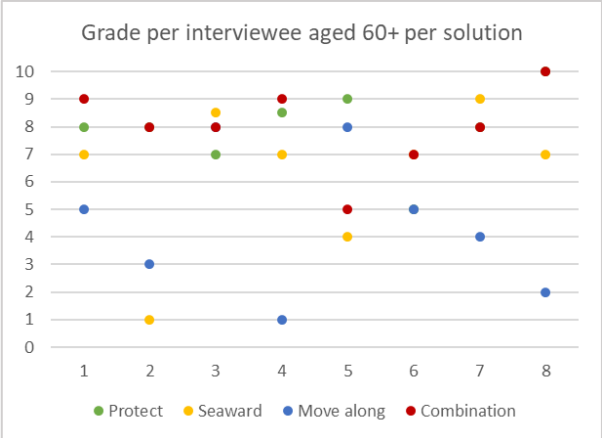


Figure 14 Grade per interviewee aged 60+ per solution

The framework for social feasibility, Chapter 4, is used to assess which arguments interviewees used to form their opinions. These aspects are explained in the remainder of this chapter.

5.2 Perception of problem

Table 2 shows what people thought about different aspects and what the difference is between the different generational groups.

Table 2 Results perception of problem

Argument	**General**	**16-30**	**60+**
Believe in sea level rise	Yes, all do	Yes, all do	Yes, all do
Believe in human part	Yes, all do	Yes, all do	Yes, all do
See danger of sea level rise	Yes, all do	Yes, all do	Yes, all do
Degree of worriedness	3: Not worried 10: Sometimes worried 1: Worried 2: Only worried for grandchildren	2: Not worried 5: Sometimes worried 1: Worried	1: Not worried 5: Sometimes worried 2: Only worried for grandchildren

Even though some interviewees were not worried about sea level rise, they all did believe that something has to be done to prevent future flooding. All interviewees thus perceive sea level rise as a real issue which requires a solution. This positively influences the average social feasibility of the solution directions as they feel that at least one must be chosen.

5.3 Perceived effectiveness

Some interviewees mentioned that they found it difficult to assess how effective a solution direction would be. Reasons for this were that solution directions could be implemented in different ways and that there were no estimations yet on the effectiveness by experts. Another aspect that made the assessment of the effectiveness difficult was the uncertainty of the amount of sea level rise, especially the amount of sea level rise after 2100.

Table 3 shows how effective interviewees feel that the solution directions will be. The categories were not given to interviewees as choices but resulted organically. Some of the interviewees who are put in the 'unsure' category are also there because they did not say if they believed it would be effective or not (even after it was asked).

Table 3 Results perceived effectiveness

Solution direction	**General**	**16-30**	**60+**
Protect	6: High chance of success 9: Temporarily effective 1: Unsure	4: High chance of success 4: Temporarily effective	2: High chance of success 5: Temporarily effective 1: Unsure
Seaward	3: Not effective 6: Temporarily effective 4: Effective 3: Unsure	1: Not effective 3: Temporarily effective 3: Effective 1: Unsure	2: Not effective 3: Temporarily effective 1: Effective 2: Unsure
Move along	6: Effective 6: Not effective 3: Temporarily effective 1: Unsure	4: Effective 1: Not effective 3: Temporarily effective 0: Unsure	2: Effective 5: Not effective 0: Temporarily effective 1: Unsure
Combination	11: Effective 3: Temporarily effective 1: Not effective 1: Unsure	6: Effective 1: Temporarily effective 0: Not effective 1: Unsure	5: Effective 2: Temporarily effective 1: Not effective 0: Unsure

Some interviewees (4, 8, 10, 13 and 14) mentioned that they did not see the move along direction as a solution, e.g. *Interviewee 13: "this is not saving the ship but immediately going into the lifeboat" and Interviewee 10: "I don't think this is a solution".* These interviewees did not directly say that they thought it would be ineffective but it was clear that they did think this.

5.4 Perceived distribution of benefits and costs

Table 4 shows how many interviewees believe the solution direction will have a positive or negative effect and how many are unsure. These categories were not given to interviewees as choices but resulted organically. Some of the interviewees who are put in the 'unsure' category are also there because they did not make a clear choice in if they saw the distribution of benefits and costs as negative or positive (even after it was asked).

Table 4 Results perceived distribution of benefits and costs

Solution direction	**General**	**16-30**	**60+**
Protect	11: Positive 5: Negative	5: Positive 3: Negative	6: Positive 2: Negative
Seaward	6: Positive 4: Negative 5: Unsure	5: positive 2: Negative 1: Unsure (if land use good than positive)	2: Positive 2: Negative 4: Unsure (if checked that extra costs worth it than positive)
Move along	7: Positive 9: Negative	5: Positive 3: Negative	2: Positive 6: Negative
Combination	15: Positive 1: Negative	8: Positive 0: Negative	7: Positive 1: Negative

It was found that the perceived effectiveness is related to the perceived distribution of benefits and costs. When an interviewee perceived a solution direction to be ineffective, they also perceived the distribution of cost and benefits to be inadequate. The perceived effectiveness is thus a precondition for the perceived distribution of benefits and costs. However, if a solution direction is perceived as effective, this does not always mean that the distribution of benefits and costs is perceived as positive as this is dependent on more aspects.

Below, the aspects that influenced how people perceive the distribution of costs and benefits are shown. No clear difference in which (types of) arguments interviewees in the different age groups use has been found. As there are some differences in how they perceive certain solutions, the interviewees likely hang different weights on different aspects. However, which aspects interviewees found important also differs a lot within each age group.

5.4.1 Nature

1, 4, 5, 9, 13, 14, 15, 16 believe that the ***protect*** direction will be bad for nature, especially the closed direction is seen as negative. Interviewee 7 believes it will be relatively good, and interviewee 2 is unsure. Many interviewees (1, 6, 7, 8, 11, 13, and 15) believe that the ***seaward*** direction is not good for nature; *interviewee 11: "you have to move a lot of sand which disrupts the North sea floor. That is a disaster"*. Interviewees 3, 9, 12 believe that the impacts on nature will be limited and thus less negative; *interviewee 12: "There are now already many windmills and that is also a consequence for the animals, I think. But if that would make a large difference, if an island was made in front of the coast, I don't believe in that.".* Interviewees 2, 3, 5, 10 and 15 believe ***move along*** will be good for nature; interviewee 7 is unsure what the net benefits are for nature because the nature that lives on the land that will be flooded. Even though interviewee 13 believes that some directions are bad for

nature, they do not see this as a main issue as they believe that human safety and benefits are more important. Interviewees 5 and 7 believe that the ***combination*** is a good balance between nature and humans and that it is relatively positive for nature in comparison to the separate solution directions. Interviewee 16 disagrees and thinks that the current combination focuses a lot on protection of the city and less on nature protection.

5.4.2 Financial aspect

Multiple interviewees mentioned that it is difficult to estimate the costs. This is likely because no estimations have been made yet by experts. It is also difficult to estimate the costs of constructing and maintaining defensive measures in comparison to the costs of other aspects such as moving existing infrastructure and houses and the effects on nature.

Most interviewees (1, 2, 5, 6, 7, 13, 16) believe that the financial costs of ***protect*** will be relatively low compared to the other solution directions. Interviewees 3 and 9 believe that it will be a very expensive solution. Interviewees 1, 2, 7, 9, 11 and 14 believe that the costs of ***seaward*** will be very high and higher than the other solution directions (both the initial costs and the maintenance costs are mentioned). Interviewees 2, 5 and 15 believe the extra costs can be earned back in the long term. Interviewees 13 and 14 are unsure if seaward is financially achievable. Interviewees 3, 10, 11, 13, 15 believe that **move along** will be very expensive; interviewees 5 and 7 also see this but think that when it is spread out over many years it will be okay. Interviewees 4 and 9 are unsure but think the costs will be lower than in other directions. Interviewees 3 and 4 mentioned that the ***combination*** will likely lead to fewer costs than any of the other solution directions. Interviewee 15 does not agree and thinks that the combination of multiple measures might lead to higher costs.

Interviewee 12 thinks that the costs of a flood are higher so something must be done and money must be invested. 5 and 11 mentioned for move along that they think that the costs will be high but that the costs will be even higher if nothing is planned and it suddenly floods. Interviewee 16 mentioned that every solution will cost a lot so as long as it works for a long time it is okay. Interviewees 10 and 13 also believe that some costs are unavoidable so that it is okay (mentioned with combination). It is also mentioned that it is better to spend some more money once than to spend it twice because it is not done correctly. *Interviewee 15: "It's better to do something right the first time than not to do it right and think, oh shit, now we have to spend it twice".*

5.4.3 Availability of land

Interviewees 1, 4 and 13 think it is difficult that a lot of land has to be made available in the ***protect*** direction so the dikes can be heightened and strengthened enough; however, they do see this as necessary to protect us from the rising sea level. Interviewee 6 also mentions this for the ***combination***. Interviewees 1, 3, 9, 10 and 12 mention that the country is already densely populated and that ***move along*** will either lead to an even more densely populated country or to having to move into another country. *Interviewee 1: "I think that we hardly have any space in the Netherlands where it would be high enough…so you will have to go to another country quickly.".*

Many interviewees (1, 2, 3, 4, 5, 9, 10, 11, 13, 14, 15 and 16) believe that the expansion of land in ***seaward*** can be useful for certain things and can provide a benefit for citizens. Most believe that it can be useful for an airport or industry so it is moved further away from citizens and there is thus less nuisance. Another potential use that is mentioned is housing. *Interviewee 9: "if you move the industry and airports there, you also keep that away from people. So you will be left with better living spaces I think.".* Even though interviewees 6 and 7 think it could be used for housing, they believe that there is enough place on existing land to build houses. Interviewee 8 also does not believe that the new land

is a benefit and believes that it will change the character of the country. *Interviewee 8: "I find it truly horrible … the character of the country is completely changed".*

5.4.4 Maintainability and construction time

Interviewees 6, 11, 15 and 16 mentioned that it is important that a solution is maintainable for a long time period. Even though the other interviewees did not mention this explicitly, it is likely that they also find this important, especially because some mentioned that some solution directions would only be temporarily effective. There was disagreement about which solution direction is maintainable for the longest time. Interviewee 6 believes protect is relatively long maintainable while 11 and 16 think it is not maintainable for a long time. Also, interviewee 15 believes seaward is maintainable for a long time while interviewee 6 believes that moving along is maintainable for longer. Interviewee 16 mentions that the combination will likely be maintainable for a long time, while interviewee 11 does not think that it is maintainable for a long time. Another time-related aspect is the necessary time for construction, as this must be doable before the sea level has risen to critical levels. Interviewees believe that protect can be done relatively quickly and seaward will take a long time to plan and construct.

5.4.5 Hinder shipping industry

Interviewee 12 thinks that the ***protect-closed*** direction will hinder shipping. Interviewees 7 and 12 mention that ***seaward*** is difficult for shipping as the islands will likely obstruct some shipping lanes. Interviewee 12 mentions that closing off the Meuse in the city centre in the ***combination*** might hinder shipping. Interviewee 9 also believes that the ***combination*** might upset some industries, such as ship makers land inwards, but that that is okay as it is necessary to protect us.

5.4.6 Novelty of solution

How novel a solution direction is also seems to be an influencing factor as a very novel concept can make it more difficult to get a good grasp on the benefits and costs. Multiple interviewees mentioned that some solution directions (mainly ***seaward*** and ***move along***) were new to them and that this made it difficult to form an opinion. *Interviewee 2: "It is quite a difficult idea for me, so I find it rather difficult to say something about this actually".* Some interviewees also mentioned that these directions seemed unrealistic. On the other hand, the ***protect*** solution direction is seen by some as the most realistic scenario, likely because most interviewees were already aware of the current flood defence system which is similar to the protect direction. The ***combination*** was explained in more detail which gave the interviewees a clearer idea of how it would look like which made it seem more thought through and also more realistic. *Interviewee 16: "because it can now be seen for a smaller area and is a bit more explained and specific, you immediately get the feeling of oh a little more thought has been put into this".*

5.4.7 Migration

Some interviewees (12, 14) do not want to move towards another area or lose their house. Some interviewees (1,2) mention that they would not mind if they had to move. For the ***move along*** solution direction, besides the emotional and social toll of moving to a different place, the financial toll of wasting the existing infrastructure and buildings is also mentioned (1, 3, 10). Interviewees 1, 2, 3 and 16 also mention that having to leave an area will cause resistance amongst citizens and that it will be difficult to convince them that it is a good solution.

Interviewee 12: "not everyone can move to the East. I mean, work is being done here in the West"

5.4.8 (inter)national cooperation

The need for cooperation both within the country and with other countries is mentioned by multiple interviewees (5, 9, 11, 10, 12, 14, and 16). The main reason that is mentioned for this is because the water does not stop at the border and a solution only for the Netherlands will not keep us safe as the water can enter the land through other countries as well. It is not mentioned as a benefit or a cost but mainly just as a side note.

Interviewee 5: "If we do this very well in Rotterdam, but Amsterdam or Noord-Holland do nothing, then you still have nothing."

5.4.9 Ethical concerns

Some potential ethical issues related to the distribution of the costs and benefits are mentioned. In some solution directions the focus lies on protecting large cities and smaller villages are largely left unprotected which can be deemed unethical. It is also mentioned as a potential issue that with some solutions, people who are living in higher-lying areas and are not concerned about sea level rise might experience negative effects. This is for example in the move along direction where many citizens will move towards those areas. Besides this, how the financial costs should be distributed between the low-lying areas and the higher-lying areas is mentioned as a difficult issue. One specific case that is mentioned is Limburg which experienced its own flooding issues in 2021 and is sometimes not even on the map of the solution directions. Furthermore, the impacts on nature might need to be compensated.

Interviewee 3: "it is of course always the question for whom it works out well."

5.4.10 Positive possibilities

Interviewees 5, 7, 8, 9, and 16 mention that it is preferred if a solution to sea level rise can be combined with more positive possibilities. Possibilities that are mentioned are recreation, nature areas, generation of energy and more housing.

Another positive possibility is if the solution to sea level rise can be combined with other issues. The importance of attempting to prevent sea level rise is mentioned by multiple interviewees (1, 3, 4, 9, 10, 13, 14). Additionally, the potential to combine the issue of sea level rise with other issues like the nitrogen crisis (14), draughts (5) and housing issues is mentioned.

5.4.11 Preparation needed

The final factor that was found in the interviews is that it is necessary to prepare citizens. This is not a benefit or cost of one of the solution directions, but it is an aspect that is important to take into account in general when creating a solution. Even though many interviewees do not think that the move along direction should be chosen as the sole solution direction against sea level rise, many (1, 8, 11, 12, 14) believe that it is good to start already investing in technologies such as floating buildings. Interviewees mention that this is useful to prepare in case a flood does happen. Another way in which preparations should be done is by informing people and making them aware that they are in potential danger. *Interviewee 11: "Prepare the people for God's sake" "If you inform people and say what is potentially coming, then everything is more acceptable".* This is also connected to interviewees (7, 8, 11, 13) thinking it should be made unattractive to live in low-lying areas and that no big investments should be made anymore in low-lying areas; they believe we should thus motivate people to move to higher areas.

5.4.12 Miscellaneous

There were also some aspects that were only mentioned by one or two interviewees and that did not fit with any of the other aspects. These are named here.

Interviewee 1 believes it would be **better if one clear direction** was chosen instead of combining open and closed.

Interviewee 8 mentions the dangers of the **digitalisation** of the system. *"it's all digitized…so that is all very vulnerable. It's just very easy to manipulate. Yes, there can be a malfunction of course. But it is also possible in major conflicts I would say."*

Interviewee 16 mentioned that protect might feel as though your freedom is limited because of high walls. Interviewee 3 thinks that because the rising sea level causes the barriers to become increasingly larger and more massive, this can eventually lead to resistance as it **reduces the liveability** of the country.

Interviewee 1 mentioned that the pumping in protect will **require a lot of energy**. Interviewee 7 mentioned that it costs a lot of energy to construct the islands in seaward.

Interviewee 15 mentions that the combination is likely **the least impactful** on citizens.

5.5 Indirect influences

5.5.1 Suggested innovation (and sanctioned discourse)

The suggested innovations were the solution directions and the combined direction that were explained to the interviewees. They were explained to each interviewee in the same manner so it is unlikely to have influenced the results. These solution directions are part of the sanctioned discourse as they are already being used in some political documents (see Appendix 1).

One thing that was found is that the visualisations can influence how people see a certain suggestion. As these visualisations have been created by experts and are also being used in political debates, it is necessary to recognise this influence as it can lead to different opinions. It is not clear how much the visualisations influenced the interviewees as this is difficult to measure and as there was no control group which did not see the visualisations. However, the influence can be seen clearly in one of the interviews as the interviewee (9) said things such as *"it wasn't a nice picture either"* and *"maybe it's the pictures too, that one on the left is also green, that looks a bit friendlier".* In other interviews, it was sometimes also suggested to have an impact based on words and phrases such as *(5) "this is very radical the way it is drawn here"* and *(2) "It also looks really futuristic".* Even though the visualisations thus could influence interviewees, they were still appreciated by many as they provided a useful impression of the solution directions which was easy to grasp.

As can be seen in the conceptual model, this can thus influence the perceived effectiveness and the perceived distribution of benefits and costs. It does not influence the perception of the problem because that is not connected to the suggested innovation.

5.5.2 Demographic factors

There are multiple demographic factors that potentially influence the way people perceive the problem, the effectiveness of the solution and the distribution of benefits and costs. The demographic factor of age is not discussed in this section as it is already incorporated into other sections as this is a large part of this research. It was also asked which type of work interviewees did and which political parties they vote for but these aspects differ very much per interviewee and no interesting results could thus be found; therefore they are not discussed.

Education

A demographic factor that could have had an influence on the opinions of citizens is previous knowledge. This is largely related to the level of education. But as almost all interviewees had (or

currently followed) higher education and only two interviewees (one 16-30, one 60+) had a lower education, no conclusion can be drawn on the effect of the level of education. There were also no clear differences between these interviewees and the higher-educated interviewees.

Gender

7 interviewees were male, and 9 were female. As can be seen in the graphs (Figure 16-18), there are no major differences in the grades that were given to the solution directions by males and females. The main difference is that the protect and the seaward directions receive a higher grade from males than from females. There are no clear differences in the arguments used to substantiate the grades.

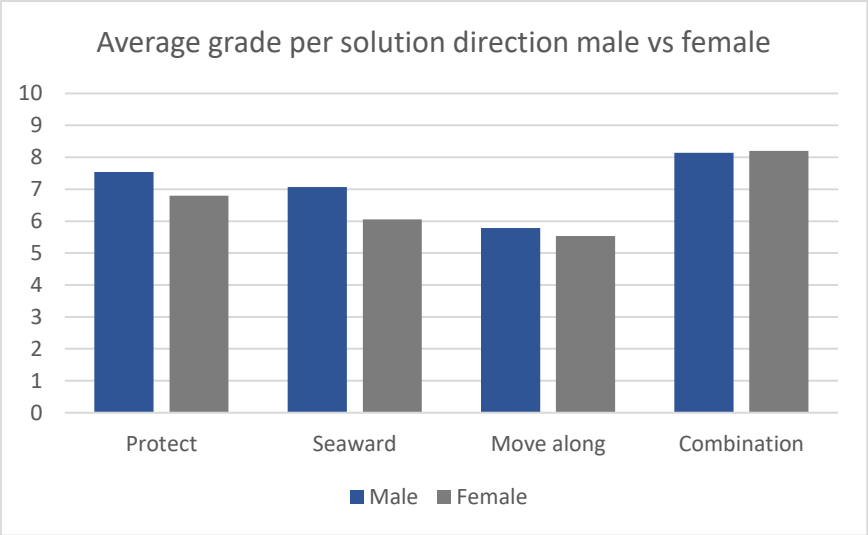


Figure 18 Average grade per solution direction male vs female

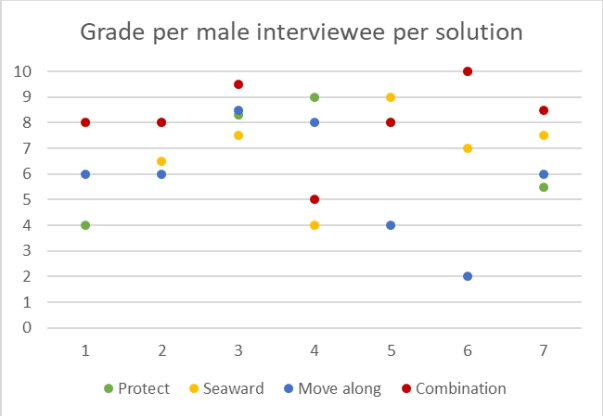


Figure 17 Grade per male interviewee per solution

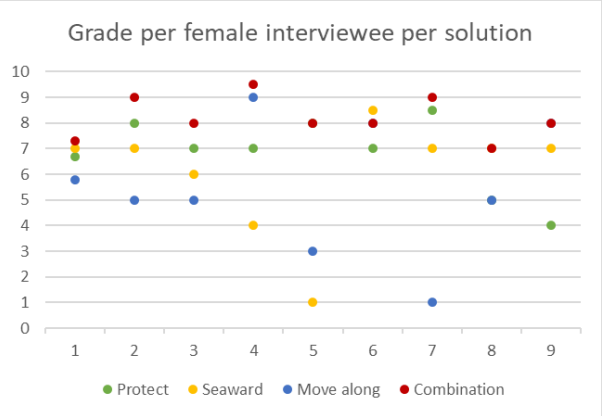


Figure 16 Grade per female interviewee per solution

The demographic factor thus does not hugely influence the social feasibility. It mainly influences the background knowledge that citizens have.

5.5.3 Interest groups

All interviewees knew of some measures to prevent flooding. Even though some people said at the beginning that they knew no measures, when pressed a bit more they mentioned that they did know some but did not know about them in depth. Everyone knew about dikes, dunes and storm surge barriers which fit with the protect measure. Some mentioned floodplains which fit with move along. Some had heard of the plans to create Schiphol on sea or knew that the Tweede Maasvlakte was built

in the sea but almost none of those people connected this with protecting the country from the rising sea level. Two people had heard of the separate solution directions; they did not know about them in depth but they had heard of the possibilities. One of these interviewees had also seen the visualisations on social media once. They had not analysed this but did know of their existence.

Some places where the interviewees learned of protection measures were social media, newspapers, television, and lectures from professionals in the field (these were often about seaward). Most of the previous knowledge that interviewees had seems to be seen as general knowledge by them which was not necessarily heard about in one place (e.g. almost everyone in the Netherlands knows about dikes).

5.6 Significance of results

The significance of the findings is often assessed in quantitative research to test if the difference between groups is statistically significant (Bhandari, 2022). This is usually not done for qualitative research as the significance is dependent on the depth and richness of the insights gained from the interviews and the rigor of the data analysis. However, as the interviewees were asked to grade the solution directions, it is possible to test the significance of these grades. As there are few data points, the significance of the results does not say much; however, it still adds some depth to the discussion of the findings.

The significance of the grades was tested in Excel. First, the grades per solution direction were compared between the 16-30 and the 60+ group. The p-values that were found are shown in Table 5. The P-value is the calculated probability which is the probability of finding the observed, or more extreme results when the null hypothesis is true (StatsDirect, 2022). The null hypothesis in this case is that the grades between the different groups are similar. When the p-value is lower than 0.5 the null hypothesis is discarded. Table 5 thus shows that only for the move along direction the null hypothesis can be discarded and that for this direction, the grades between the 16-30 and the 60+ groups are thus significantly different. The grades for the other solution directions are too similar between the different generations to be significantly different.

Table 5 Significance of the grades between age groups

Solution direction	**P-value**
Protect	0.057
Seaward	0.719
Move along	0.046
Combination	0.570

To test the significance within the age groups, a Kruskal-Wallis test has been done. This was done with an online Kruskal-Wallis Test Calculator[2]. The grades of the different solution directions were compared for each age group. Table 6 shows the results. It can be seen that the general grades and the separate age groups have a significant difference between the solution directions as all p-values are lower than 0.05. This means that the grades between solution directions within each age group are significantly different.

Table 6 Significance of the grades within an age group

Age group	**P-value**
General	0.004
16-30	0.028
60+	0.021

[2] https://www.socscistatistics.com/tests/kruskal/default.aspx

5.7 Interpretation of results

These results showed that almost all interviewees preferred a combination of the solution directions. This was somewhat expected as the combination was explained in more detail and therefore seemed better thought through and gave a clearer impression of the impacts. Furthermore, in the combination, the costs and benefits were already slightly balanced as the reason for combining the solution directions was to create a better balance. This can also be seen in the results as nearly all interviewees saw the combination as a good way to achieve a beneficial distribution of benefits and costs. It is not certain if the interviewees thus saw the combination as the best solution because of how it was presented or because they actually believe it to be the best solution.

Another notable aspect is that in contrast to the original model, now concrete factors have been found that interviewees mentioned to be important in their assessment of the perceived benefits and costs. The factors that were found to be of importance to multiple interviewees are: nature, financial aspects, availability of land, maintainability and construction time, hinder to the shipping industry, novelty of the solution, migration, (inter)national cooperation, ethical concerns, positive possibilities. These were not brought to the interviewees but originated naturally. Furthermore, the need to prepare citizens for a potential flood was also mentioned by multiple interviewees. Recurrently interviewees assessed the benefits and costs of one solution direction likewise but saw the overall balance differently. An example of this is that multiple interviewees thought that nature would be harmed by a solution direction but they had a different opinion on how bad this was and gave the overall measure differing grades. It is thus likely that interviewees held a different level of importance to differing aspects.

All interviewees believed in the seriousness of sea level rise. The problem was thus perceived as a serious issue that requires a solution. Even though this is the case for this sample, this does not mean that all citizens of Rotterdam have the same beliefs. Many interviewees found it difficult to assess the perceived effectiveness as multiple implementations of the separate solution directions were possible. More research is thus needed to gather the technical details of the potential solutions before it can be assessed if citizens perceive them as effective.

The most interesting result related to the generational differences is that the move along direction is not feasible amongst the 60+ group, whilst this is socially feasible amongst the 16-30 group. Moreover, the interviewees in the 16-30 group graded all potential solutions relatively close to each other, whilst the 60+ group had much more variating grades. No differences in the arguments used to substantiate the grades were found, it is thus likely that the interviewees held different weights to different aspects.

6. Adaptations to the framework and academic and social implications

This chapter answers the last subquestion: [S3] *"What are the academic and social implications of the findings of the social feasibility of solution directions for sea level rise amongst citizens in Rotterdam?"*. First, the conceptual framework for social feasibility that was created in Chapter 4 is adapted according to the findings from the interviews. Secondly, the implications for academic literature are explained, which includes some changes to the initial conceptual model for social feasibility. After this, the implications for society are explained.

6.1 Post-interview framework for social feasibility

During this thesis, a new conceptual model was derived from the framework of Feitelson and Salomon which showed which aspects influenced social feasibility (Section 4). This section discusses the findings related to this conceptual model and shows some adaptations that have been made according to the findings from the interviews. This will be done by first discussing the direct effects, then the indirect effects, and finally showing the new framework.

6.1.1 Adaptations to direct effects

The first direct effect that will be discussed is the perception of the problem. Even though the interviews did not show any interesting findings regarding the perception of the problem as all interviewees believed in sea level rise and the potential danger, it is still important to include as there are people who do have different views. It is very likely that with a larger sample size, people would be interviewed who do not believe in sea level rise; in this case it can be expected that the perception of the problem has a large influence on how potential solutions are assessed. It has been clarified which problem is meant with this effect by adding that it is about climate change and sea level rise.

The results showed that the perceived effectiveness is also important for social feasibility because when people think that a solution direction will not be effective to keep us safe, they do not want it. This can be seen because solution directions that people thought would be less effective (Table 3) are also given lower grades (Figure 11). For citizens to be able to estimate the effectiveness of solution directions, they must have a clear understanding of what the solution direction entails and what the technical aspects are. Currently, the solution directions are a bit vague as they encompass different types of measures that can be used to different degrees. There are also few technical assumptions made about for example the estimated sea level rise the solution directions can accommodate and how much risk there is that they fail. This made it difficult for interviewees to assess whether a solution direction would be effective in keeping us safe from sea level rise. It can thus be seen that the link between the suggested innovation and the perceived effectiveness is strong as how the suggested innovation is explained influences the perceived effectiveness. No adaptations to the framework are made for this effect.

There are also little estimations for the costs and effects that each solution direction has which made estimating the distribution of benefits and costs also difficult for the interviewees. However, because this is less about the technical aspects and more about what citizens find important, some interesting results were still found. Section 5.4 shows which aspects interviewees used to substantiate their opinions. These aspects are added to the framework for social feasibility as they provide a basis for potential benefits and costs that could influence how people perceive the distribution of benefits and costs. Some benefits and costs have been slightly adapted so it is clearer what they entail. There are a couple of large changes that have been made. First, 'maintainability and construction time' has been separated as this includes two different aspects. Second, 'preparation needed' is not included as already mentioned, this is not a clear cost or benefit but more a general aspect that is necessary.

Finally, miscellaneous is not included as this list only includes potential benefits and costs and is thus not a definite list of which aspects people perceive.

Besides the addition of the potential benefits and costs, the order of the direct effects has been changed. This does not mean that one effect is more important than the other, however, an order of dependence was found. Namely, if a solution direction was thought to be ineffective, the distribution of benefits and costs was always negative as there were no benefits and there were still costs. In the final version of the framework (Figure 19) the first direct effect is the perception of the problem; while this was not found to be of high influence in this research as all interviewees thought that sea level rise was a serious issue, it is still of high importance as there are people who do not view sea level rise as a serious issue and they are thus unlikely to see the need of solution directions which causes the effects of the perceived effectiveness and distribution of benefits and costs to be lower. The second direct effect is the perceived effectiveness and the third direct effect is the distribution of benefits and costs. This has been chosen as the measure in the first place needs to be effective before other benefits and costs matter.

6.1.2 Adaptations to indirect effects

The first indirect effect in the conceptual model of Chapter 4 is the suggested innovation. This includes how a solution direction is explained and which sources are used to explain it influences the opinion of citizens a lot. You cannot assume that something will be explained without any biases because, especially for a complex innovation, there are a lot of factors and effects of the innovation and it is very difficult to name everything in a short explanation time. It is thus important to realise that there is always some form of bias introduced by the interviewer. In this thesis, this was seen as the visualisations influenced interviewees. Also, the combined approach was explained more in-depth which is likely part of the reason why this was chosen as the highest-ranked alternative. As there is thus an influence of how the suggested innovation is explained, this is added to the framework by adding the box 'communication'. This is a wavy box so it demonstrates that the suggested measure is not always explained perfectly and the line between the explainer and the listener is not always clear.

In the conceptual model of Chapter 4, the previous knowledge was included through the interest groups as these have created this previous knowledge. However, it was deemed that this was not the best term for this as there is not always a clear interest group which creates knowledge in citizens but some part of it is also general knowledge (for example, almost everyone in the Netherlands knows something about dikes). In the new model, the previous knowledge is thus a separate box.

The demographic factors of citizens influence the previous knowledge of citizens and do not have a direct impact on their perceptions. This is because there were limited findings on the demographic factors and it was mainly seen that they influenced the previous knowledge which in turn influenced their perceptions.

The box 'sanctioned discourse' has been removed from the framework as the suggested measures are already included in the sanctioned discourse. Furthermore, the influence of the sanctioned discourse is included through the interest groups. In the new framework, this box also includes examples of what these interest groups can entail.

Finally, the order of the indirect effects has changed to show that the demographic factors and the previous knowledge are the first aspects that interviewees encounter. The suggested mitigation measures for sea level rise are only introduced at the interviews so these are seen later.

6.1.3 Post-interview adapted framework

Figure 19 shows the conceptual framework for the social feasibility of mitigation measures to sea level rise.

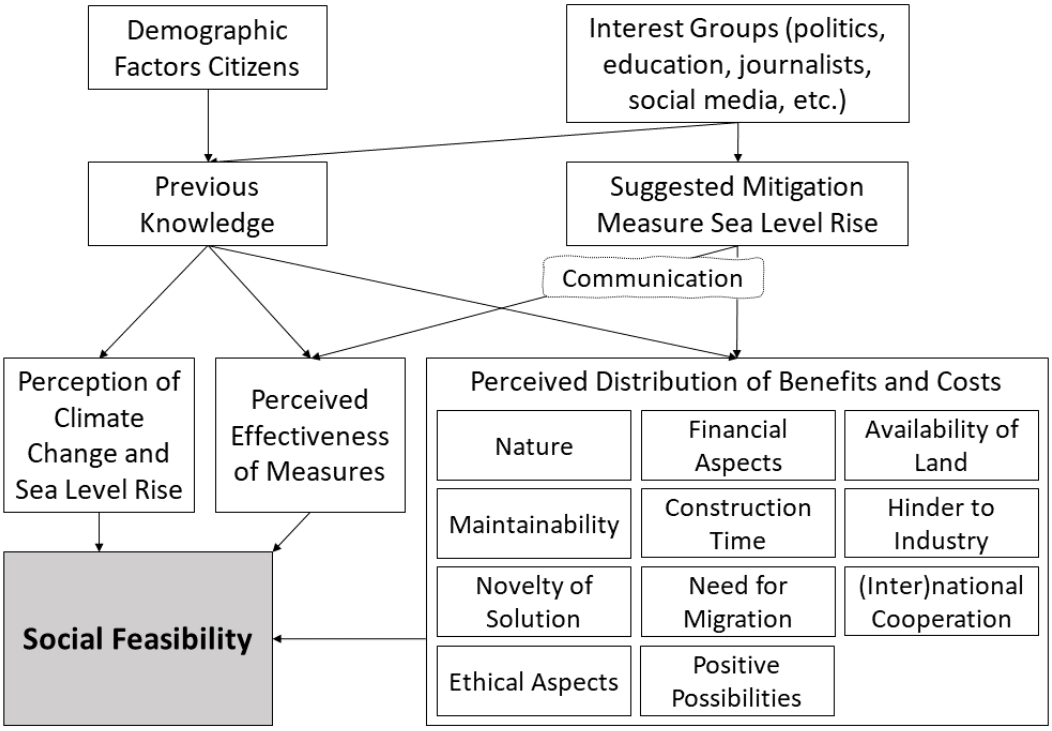


Figure 19 Framework for the social feasibility of mitigation measures to sea level rise

This framework can thus be used to assess the social feasibility of measures to mitigate sea level rise. This can be done either on an individual or a collective basis. For an assessment on an individual basis, it is first important to assess how the citizen perceives climate change and sea level rise. If they believe this to be unimportant, it is likely that they also do not feel that a solution is needed; however, if they believe that it is a large and urgent problem, they likely have more support for the solution. Secondly, the measure to mitigate sea level rise must be effective. If a citizen does not believe that it will be effective, the solution is unlikely to be seen as feasible. Finally, the solution must have a positive distribution of benefits and costs. The framework shows which aspects citizens could use in their assessment of the costs and benefits. How these aspects are regarded and how important they find each aspect differs per citizen as many involve personal preferences. The way these three aspects are perceived depends on indirect effects such as the previous knowledge of the citizen, and the way that the suggested mitigation measure against sea level rise is communicated. The collective social feasibility can be assessed by taking the individual feasibility of multiple citizens and seeing what the overall opinion is.

6.2 Academic relevance

This section first explains the contributions this thesis made to the academic literature on social feasibility and especially the framework of Feitelson and Salomon. After which, the contribution to the literature gaps will be explained.

6.2.1 Contribution to the framework of Feitelson and Salomon

The framework for social feasibility is useful to assess the social feasibility of innovations or existing technologies that will have to be implemented at a larger scale than has currently been done. It provides a new perspective on which factors influence social feasibility and how these factors are

interconnected. The factors that influence social feasibility are similar to the ones in the framework of Feitelson and Salomon, however, there are some differences. The framework of Feitelson and Salmon is thus not fit to assess the social feasibility and this thesis created a framework that is better able to assess this.

Compared to the framework of Feitelson and Salomon, the new framework only focuses on social feasibility and thus provides a more in-depth view on this. The economic, technical and political feasibility are included indirectly through the suggested mitigation measures. Besides this, these aspects play a role in the perceived effectiveness and perceived distribution of benefits and costs. This adapted framework has thus a more specific focus on social feasibility compared to the general framework from Feitelson and Salomon. It goes more into depth on how to assess if a solution to sea level rise is socially feasible. This framework can be used for more than just assessing solutions to sea level rise but is likely to also fit other innovations. The potential benefits and costs that were found during this research are for solutions to sea level rise, but it is likely that there is a large overlap with other innovations. As they are potential benefits and costs and not definitive, it is also not necessary that all benefits and costs are found for each innovation. It is also possible that other benefits and costs that have not been listed here are found.

In the framework of Feitelson and Salomon the social feasibility is included as the likelihood that the majority of voters support the innovation; while in this adapted framework the social feasibility can also mean individual feasibility as it can differ per person. When many individual feasibilities are assessed, the collective feasibility can be estimated. This adapted framework can thus be used both for individual feasibility and for collective feasibility.

6.2.2 Contribution to literature gap

No literature was found on the opinion of citizens on drastic future measures against sea level rise. This thesis has contributed on fulfilling this knowledge gap. It was found that in general drastic future measures are socially feasible and seen as something that is needed to keep the Netherlands safe. Less drastic measures were generally preferred as the combination of solution directions was graded the highest. The second highest graded solution direction was the protect direction, which is most similar to the current strategy and thus relatively mild. It was also found that interviewees in the 60+ group were more opposed to drastic measures than interviewees in the 16-30 group. Interviewees in the 16-30 group saw the relatively drastic directions seaward and move along as adequate potential solutions to sea level rise.

The literature review further showed that there is no consensus on the difference in opinions on climate change amongst different generations. Some literature showed that people under 35 are likely to feel more stressed about climate change and global warming than older generations. Additionally, younger generations were found to experience more negative emotions in reference to climate change. However, other research found that there are reasons for elderly citizens to care about the impacts of climate change and to feel a need to find a solution. The results of this thesis are more aligned with the second type of argument, as they showed that both age groups felt a similar worry about climate change. The findings did not show that younger generations were more worried or had more negative emotions than older generations.

6.3 Societal relevance

The societal relevance of this research is twofold. First, the potential use of the conceptual framework for social feasibility. Secondly, the findings related to the social feasibility of the solution directions for sea level rise.

The conceptual framework can be used to assess the social feasibility of many innovations or existing technologies which could potentially be implemented in society. This is needed so it can be assessed whether people are likely to accept a technology or whether some aspect is missing. In the case of a missing aspect, the (implementation of the) technology can be adapted so it is socially feasible and thus likely to be accepted by the public.

The findings for the social feasibility of the solution directions for sea level rise showed that a combination of different directions is preferred by most citizens. The opinions on how the different directions should be combined differ but some form of combination is preferred. There are multiple reasons for this. Firstly it is seen as relatively effective compared to the other solution directions; a potential reason for this is that the measures in this combination are explained more in-depth which results in people thinking that it is better thought through. Secondly, it is seen by almost all interviewees as an acceptable compromise between different benefits and costs such as nature, consequences for humans and financial costs. When politicians make a final decision on which measures to implement to protect the country from sea level rise, it is thus important that they take these aspects into account as this will likely lead to high social acceptance of the measures.

7. Discussion: limitations and future research

This chapter discusses the limitations of the research and explores some ideas for future research.

7.1 Aspects related to interviewees

A limitation of this research is that the findings cannot be generalised. As mentioned in the methods, all interviewees were found through my own (extended) network. This caused almost all interviewees to be higher educated and relatively wealthy (or for many in the 16-30 group, likely to become wealthy once they start working). It is thus not representative of all citizens in the municipality of Rotterdam. Even though generalising the results is not possible, the results are still useful to provide a first insight into the opinions of citizens. Furthermore, they provide a basis for which aspects around a solution for sea level rise are of importance to citizens.

Future research is thus needed to assess if the findings differ for lower-educated citizens. One difficulty that was found during this research when attempting to interview lower-educated citizens, was that they often felt that they would not have enough knowledge to participate in the interviews or that they felt that the interviews took too long. Therefore an alternative method to assess the opinions of these citizens must be found. An appropriate method might be a questionnaire as this takes less time than an interview. Furthermore, it takes less time to analyse the results so more data could be gathered in less time. The findings of this thesis could be implemented in the questionnaire through for example asking citizens to rank the benefits and costs discussed in section 5.4 according to how important they feel they are and how much they feel that they are represented by each solution direction.

Another aspect about the interviewees that took part in this research is that they all believed in the seriousness of sea level rise and thus believed that a solution was necessary to keep the Netherlands safe. However, not all citizens believe in sea level rise and the results could change if the opinions of these people are included. Therefore it would be interesting for future research to assess the opinions of people who do not believe in climate change and sea level rise. A possible finding could be that the perception of the problem is of high importance to the social feasibility of a solution to sea level rise.

7.2 Aspects related to the chosen solution directions for sea level rise

Another limitation of this research is that the solution directions that were explained to the interviewees were not always clear. Each solution direction included multiple measures and different degrees to which these could be implemented. This creates the possibility that interviewees interpreted them differently. Furthermore, it made it difficult for interviewees to assess the effectiveness and the benefits and costs. Therefore, for future research, it is important that clearer solution measures are provided so the effectiveness and related benefits and costs are better understood. A related need for future research is thus in the creation of more specific solutions to sea level rise and to assess their technical, financial and social impacts.

Besides the explanation of the chosen solution directions, there is also the matter of the choice of these solution directions. It would also have been possible to explain alternative solutions to sea level rise in a different manner. For example, it could have been possible to explain it through existing solutions in different areas of the world or to provide clear specific measures instead of a wide array of measures. As mentioned, the choice for the solution directions has some limitations; however, there are positives and negatives to each choice for an explanation of alternative solutions to sea level rise. The reason for choosing the solution directions was because they are mentioned in Dutch policy documents and thus likely to be used in decision-making. This causes this research to be able to better fit in the current discourse.

The solution directions were shortly explained to the interviewees so they could give their opinions on them. This explanation was kept short so the interview would not take too much time. This led to the need to choose which aspects of the solution directions to include in the explanation and which to exclude. Even though this was done as thoroughly as possible to ensure as little bias as possible was included, this cannot be insured and it is thus possible that some bias of the researcher was present.

A final aspect related to the solution directions for which future research would be interesting, is the finding that the combination was perceived as having a highly favourable benefit-harm distribution by many interviewees. It is not certain if this is because the interviewees find it truly the best solution or because it is explained in more detail than the other solution direction. It should thus be assessed in future research why the combination is perceived as having such a favourable benefit-cost distribution. Furthermore, the type of combination which interviewees prefer is unclear. This research only discussed one method of combining the solution directions, but there are more possibilities for combining them. Therefore future research should be done on which combination citizens prefer. This could for example be done through assessing how much citizens feel that certain solution directions should be represented in the final solution or by presenting all solution directions with a similarly clear plan and assessing which is preferred in this case.

7.3 Aspects related to the conceptual framework for social feasibility

There is also potential for future research related to the conceptual framework for social feasibility. Firstly, it should be assessed if the conceptual model is the same for a different population group (e.g. lower educated). Secondly, it should be assessed if the conceptual model is applicable to different innovations than solutions to sea level rise.

8. Conclusion

This MSc thesis aimed to answer the research question: *"What is the social feasibility of the solution directions for sea level rise amongst different generations in the municipality of Rotterdam?".* This was done through creating a conceptual framework to assess the social feasibility, this was based on the framework of Feitelson and Salomon. After this, interviews with citizens of two generations, 16-30 and 60+, in Rotterdam were conducted to assess their opinions. The conceptual framework to assess the social feasibility was adapted after the findings of the interviews.

Four potential solutions were assessed. These consisted of three separate solution directions – protect, seaward and move along – and one combination of these directions. It was found that of the three solution directions, most interviewees preferred the protect strategy, followed by seaward and move along. However, almost all interviewees preferred the combination of the solution directions. This was somewhat expected as the combination was explained in more detail which made it seem more thought through and also gave a clearer picture of the impacts. The combination was also seen by nearly all interviewees as having a good distribution of benefits and costs, this is likely because it is more balanced than the separate solution directions.

It is interesting to see that the 60+ group on average dislikes the move along direction, whilst this is relatively popular in the 16-30 year group. Amongst the 60+ group, the move along direction is not socially feasible; however, on average, each solution direction is socially feasible. Another difference between the generations is that the interviewees in the 16-30 group graded all solutions relatively close to each other, whilst the 60+ group had very varying grades. The cause of these differences is not clear as both groups provided roughly the same arguments. It is thus likely that citizens held different weights to different aspects.

The framework for social feasibility shows that three factors directly influence the social feasibility: the perception of climate change and sea level rise, the perceived effectiveness of measures and the perceived distribution of benefits and costs of the solution. The perception of the problem was highly present amongst the interviewees as all interviewees agreed that sea level rise was a serious issue that required a solution. The opinions on the effectiveness of the solution directions differed and the main conclusion that can be drawn on this aspect is that more research is needed so clearer data can be presented to citizens. However, the opinion on the effectiveness is similar to the overall preference of citizens. For the perceived distribution of benefits and costs also more research is needed on the effects of the solution directions; however, most people were able to form an opinion based on aspects they found important.

In the perceived benefits and costs, many overlapping aspects that interviewees used to assess the benefits and costs were found. These were not brought to the interviewees but they originated naturally. These aspects are: nature, financial aspects, availability of land, maintainability and construction time, hinder to industry, novelty of solution, need for migration, (inter)national cooperation, ethical aspects, and positive possibilities. The opinions on these aspects differed but overall the perceived distribution of benefits and costs was similar to the overall preference of the solution directions.

Besides the direct influences on the social feasibility of solutions to sea level rise, there are indirect influences on the opinion of solution directions. These can be categorized into previous knowledge and suggested mitigation measures sea level rise. These can be influenced by multiple interest groups, for example, politics, education, news sources and social media. In the interviews, it was seen that how a solution direction was explained influenced the opinions of citizens. This was mainly seen through the influence that the visualisations had on how a solution was perceived and by the fact that one of

the four solutions was explained more in-depth. This factor is included in the framework through a box named communication. Furthermore, the previous knowledge of interviewees had a significant influence on how a solution was perceived as novel solutions were more difficult to grasp. The previous knowledge that interviewees had differed and ranged from basic knowledge about dikes to in-depth knowledge about a solution direction. This is also influenced by the demographic factors of citizens as people have different backgrounds and therefore different knowledge.

The social feasibility of the solution directions for sea level rise thus differ per interviewee but overall it can be said that each solution direction is socially feasible under some preconditions. The most important precondition is that there is a clear plan for how the new situation is going to look including the technical, financial, environmental and otherwise important aspects. Furthermore, it is mentioned by multiple interviewees that it is important to ensure that citizens are prepared for a potential flood. The feasibility for different generations differs as interviewees in the 60+ group had a different preference compared to interviewees in the 16-30 group; however, no clear origin for this was found as they did mention similar aspects which they found important. It is thus likely that different generations value different aspects with differing weights.

This thesis contributed to the academic literature by filling part of the knowledge gap on the opinions of citizens on drastic future measures against sea level rise. Furthermore, a contribution to the academic literature on how different generations see climate change was made. Academic literature showed no consensus as some found that the opinions differed whilst others thought they were similar. This thesis found that there is not much difference in how different generations view climate change as both age groups feel the seriousness of it and see a need for a solution. Finally, this thesis showed that the framework of Feitelson and Salomon cannot be used solely to assess the social feasibility of a certain innovation. This thesis filled this gap by providing a framework that can assess the social feasibility of mitigation measures to sea level rise.

The societal relevance of this thesis has two aspects. Firstly, the conceptual framework for social feasibility can be used to assess if a technology is likely to be accepted by the public when it is implemented. This is useful to limit the potential social backlash when a new technology is implemented. Secondly, the findings of the social feasibility of the solution directions for sea level rise can be used by politicians to create a definitive solution. This thesis shows that the final solution should be a combination of different solution directions and should in the first place be effective, and next should have a positive balance of the different benefits and costs shown in the conceptual model.

Finally, some limitations and some ideas for future research are given. The first is that this research cannot be generalised as the number and diversity of interviewees were limited; future research could include a larger and more diverse sample to make the findings generalisable. Secondly, more research is needed on the technical details of the solution directions so citizens can better understand the effectiveness and impacts and are better able to make a decision. The next point for future research is an assessment of why the combination was assessed as the best solution to sea level rise. This also includes an assessment of the preference for this specific combination or a different combination of the solution directions. Finally, future research on the conceptual framework for social feasibility is needed in two aspects. It should be assessed if the conceptual framework is the same for different population groups and if the framework is applicable to technologies other than solutions to sea level rise.

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Appendices

A1. Adaptation possibilities

This Appendix summarizes the solution directions from Deltares (Haasnoot et al., 2019) as the way to explain possible methods of adapting the Netherlands to sea level rise to citizens during the interviews. These solution directions encompass almost all possible adaptation measures. It is unlikely that one of the four solution directions will be chosen as the sole direction; but, it can be useful to showcase which possibilities there are. This chapter will explain how these directions are used in politics and what they entail. As the solution direction do not have to exclude each other, section 0 shows a visualisation which combines multiple directions.

A1.1 Solution directions in politics

Since the report (Haasnoot et al., 2019) was published, the four possible adaptation pathways are mentioned in multiple policy documents that discuss potential solutions to sea level rise. They are for example used in a document that discusses potential building blocks and adaptation paths for adapting the Netherlands to the rising sea level (Haasnoot & Diermanse, 2022). They are also mentioned in the knowledge programme for sea level rise (Deltaprogramma, 2022).

When looking for projects to actually implement, the four directions are quite broad as each direction has different ways in which it can implemented. Therefore you see that in the planning of projects the four pathways are not always named. However, projects are sometimes classified as one of the directions. This can for example be seen in the 'kennisprogramma zeespiegelstijging (Spoor IV)' (Deltaprogramme, 2022) which is the knowledge programme about sea level rise from the Dutch government. Here they classify the pitches for new plans to protect the Dutch Delta in the four solution directions. The four directions can thus be seen as a way to classify possible solutions to sea level rise.

Even though the four directions are thus often named as a way to classify projects, not all sites mention all four directions. For example, the webpage 'Maatregelen tegen overstromingen' (*measures against floodings)* (Ministerie van Infrastructuur en Waterstaat, 2022) does not discuss all directions but only focuses on the protect direction. They thus leave out the directions seaward and move along. This is despite the fact that this webpage seems to summarize all possible measures. It is possible that this happened because the current measures that are being taken to protect the Netherlands against sea level rise, fit best with the direction protect.

No other general types of adaptation measures are showcased in recent political documents. They either name the four solution direction or they only focus on very specific projects and do not look at adaptation measures on a larger scale.

A1.2 Solution directions

In the introduction and the previous section it was already mentioned that several solution directions for sea level rise in the Dutch Delta exist, these will be explained more in-depth in this section. The four solution directions have been created by Deltares (Haasnoot et al., 2019) and describe possible pathways for solutions for the management of water in the Netherlands for large increases in sea level (+2 till +4 m). The categories do not exclude each other but different measures from different solution directions can be combined.

Each direction is represented in a visual manner. This is not necessarily how the Netherlands would end up if a direction is chosen as measures can also be combined; however, it does provide a good overview of what each direction entails. Table 7 summarizes each measure.

A1.2.1 Protect open

Protect open means that the Netherlands would be protected by measures such as dikes, dunes and storm surge barriers. Protecting the land fits well with areas with a high socio-economic value as with an increasing sea level rise, the costs to protect the land will remain higher. Rivers would remain in open connection with the sea and the ports can thus remain open. Besides coastal protection measures, extra measures such as higher and wider dikes next to rivers are needed as the water level in the rivers will rise along with the sea level. Storm surge barriers can be used to temporarily close off rivers in case of storms.

The main limitation of the protect-open direction is that it is not sustainable for large levels of sea level rise (1 - 1.5m) as the storm surge barriers would have to close more and more often. For example, the Maeslantkering will have to close so often at 1m sea level rise that an alternative must be found. Higher closing levels in combination with higher and stronger river dikes can make the closable barriers remain in function longer; however, at a certain time the strength and hight of the barriers will not be enough and they can fail. The alternative is to create a lock instead of a barrier and thus make the change to the second solution direction which is protect-closed which permanently closes off the rivers from the sea.

At the same time, salty water will get further land inwards through rivers and groundwater. An increase in salinity in the surface and groundwater leads to a need to change the fresh water supply or the fresh water related activities (e.g. agriculture). Higher groundwater pressure could also lead to eruption of the ground.

The technical feasibility of protect open has multiple aspects. When the closing level of storm surge barriers is increased, they have to be strengthened. This also means that the dikes in the hinterland have to be heightened as the water level will rise in the rivers, this also requires more width which is currently not possible everywhere. The pumping capacity will also have to be increased to ensure that the water can be pumped towards the sea. The storage of river water will also become more challenging. Finally, sand replenishment must be scaled up, as a rule of thumb it can be assumed that for each mm of sea level rise, 7milion m3 extra sand is needed to replenish coastal areas and estuaries. For only the coastal areas, roughly 4 million m3 per mm of sea level rise is needed. It is unknown if there are limits to the upscaling; but, larger volumes do require different methods of organisation, execution and funding.

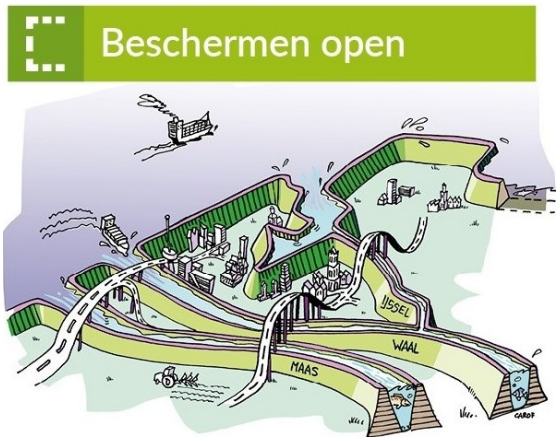


Figure 20 Protect-open (Feldbrugge, 2022)

A1.2.2 Protect closed

Protect-closed means that the coast will be protected against rising sea levels through hard or soft measures such as flood defences, sand nourishments, wetlands, dams and storm surge barriers. Protecting the land fits well with areas with a high socio-economic value as with an increasing sea level rise, the costs to protect the land will remain higher. The rivers will be closed of from the sea and the river water then needs to be pumped out to the North Sea. This method is not very flexible as most measures will be fixed.

One option for adapting to rising sea level, is to heighten and reinforce existing dikes. But when a dike must be heightened/reinforced, more space is needed. The widened dikes could be combined with other purposes such as housing, recreation or nature. It is also possible to create an extra dike which ensures that the second dike is hit less hard. This would mean that the land in between the dikes can temporarily flood.

There are also other softer methods of protection that do not directly protect us from flooding but do help. The first is to create breakwaters which dampen waves before they reach the coast which reduces the erosion of the coast and dikes. They do not protect against storms or sea level rise but they do ensure that dikes will last longer. Furthermore, vegetation can help to dampen waves and lessen erosion. Finally, sand supplementation can help to ensure that dunes grow higher.

To close off rivers such as the Meuse and the Rhine from the sea, permanent flood defences including pumps must be build. The water in the hinterland must also be kept at a steady level. One side effect of closing off the rivers, is that salt intrusion will be limited to coastal areas which limits the impacts on fresh water supply. However, it also means that nature will suffer as intertidal zones will be closed off and sand replenishment will have large consequences for water life.

In terms of technical feasibility, the draining of rivers will be a big challenge. In the southwest Delta pumps need to be installed with a high capacity (9000 m3/s). It is therefore logical to partly drain (spui) the river water. To accomplish this, water must be stored in the rivers during high tides. This requires water storage areas, stronger and higher inland dikes and polder pumping stations. At the same time, current coastal protection measures will have to be adapted with rising sea level. Storm surge barriers have to be adapted and dikes will have to be heightened. Higher dikes also require more width which is currently not possible everywhere. Sand replenishment must be scaled up, as a rule of thumb it can be assumed that for each mm of sea level rise, 7milion m3 extra sand is needed to replenish coastal areas and estuaries. For only the coastal areas, roughly 4 million m3 per mm of sea level rise is needed. It is unknown if there are limits to the upscaling; but, larger volumes do require different methods of organisation, execution and funding.

Figure 21 Protect-closed (Feldbrugge, 2022)

A1.2.3 Seaward

The third solution direction is seaward. This involves the creation of new, higher and seaward land to protect the delta from flooding. Besides being able to create new seaward coastal defences, the extra space can be used for housing, nature, recreation, transport, energy generation and other things. An example of seaward is to create a new strip of land which separates a lake in front of the coast. This reduces the pressure on dikes further land inwards. Islands in front of the coast can also function as breakwaters and also provide spaces for living, industry and other activities.

A new closed off coast will be able to withstand a higher sea level rise than only the creation of islands. In this way, the old coast will be protected by a ring of new, higher dikes of islands and water barriers. The old coast will still have to be maintained. Salt intrusion and seepage of water can still happen but will be reduced to coastal areas. River water will have to be pumped out towards the sea so space for fresh water storage is needed. A coastal lake provides space for this and could even lead to a lesser intrusion of salt and also provide a storage space for extremely high waters in rivers. Fresh water supply and large inland dikes are therefore less limiting factors than in the protecting option.

Limiting factors for seaward can be the necessary pump capacity, and the amount of sand needed for the creation of islands or the extension of the coast. A lot of sand supplement is also needed to maintain the new coast. Furthermore, there are large impacts on the nature in the North Sea as the ecological habitat will change. One of these impacts is that large fresh water lakes can lead to strong eutrophication and oxygen deprivation of the water.

In terms of the technical feasibility, new sea defences are necessary and it must be chosen if islands will be created or if existing land will be extended. As is already mentioned, sand will be a limiting factor in the decisions on how much new land can be created. The maintenance needs are dependent on the length and character of the chosen measures. The draining of the rivers will be a similar challenge to the protect strategy; however, the area between the islands and the current coastal line can be a space for storing excess water which can reduce the necessary pump capacity. By keeping these coastal lakes at a low water level, the dikes next to the rivers can also be unburdened which can reduce the need for dike heightening.

Figure 22 Seaward (Feldbrugge, 2022)

A1.2.4 Move along

The final category to adapt to the consequences of rising sea level, is to move along with the water. This means that you lower the vulnerability to the consequences of a higher sea level by using salt-tolerant agriculture, elevating the land, spatial planning or migration.

Salt-tolerant agriculture and elevating the land can help to protect against (the effects of) floods. Buildings can be made flood proof by building them on poles or mounds (terpen), but this solution may not be effective for an extra increase of sea level rise as they are difficult to adapt. It is thus mainly useful when only part of the time water reaches the land. Another option for moving along with the water is to create floating islands, cities or homes, which can adjust to rising sea levels in a flexible way. This method can handle higher levels of sea level rise. In addition, it is possible to temporarily overflow a part of the land so sediment can settle in the polders which will heighten them in a natural way. One downside of this method is that it can make the land more saline which limits the possible uses. Finally, permanently leaving land to the sea is an option. This involves migrating and thus moving cities and activities to higher and more protected areas.

The technical feasibility of these measures differ. It is possible that with some of these measures it is not necessary that new flood defence barriers are created. Existing barriers can still be used to reduce water levels during storms. It is thus likely that it is not necessary to close off rivers and install pumps to drain water.

Figure 23 Move along (Feldbrugge, 2022)

A1.3 Summary of the solution directions

An overview of some technical aspects of the solution directions is seen in Table 7.

Table 7 Summary of solution directions

	Protect-closed	**Protect-open**	**Seaward**	**Move along**
Amount of sea level rise	Till a few meters	1m for current barriers, with changes 1-2m	1m for open version with islands, few meters for closed variant or land expansion	Limited for poles or mounds; much by floating or migration
Technical feasibility	Availability of sand is unknown. Large pump capacity and temporary storage for river water is needed.	Availability of sand is unknown.	Need a lot of sand. Large pump capacity and temporary storage for river water is needed.	Innovation needed for heightening urban area.
Social feasibility	Closing of rivers will lead to much resistance. Increased costs and lack of space for dyke heightening and strengthening. Large consequences for nature.	Increased costs and lack of space for dyke heightening and strengthening.	Huge investment. Large consequences for nature.	Local or for new development. Poles and mounds only acceptable for temporary floodings. Sacrificed land will lead to a lot of resistance.
Adaptivity	Next 20 years: room for dykes/rivers needed. When following current plan, delta management will lead to this.	Next 20 years: a lot of room needed for dykes/rivers. This is the current path, will eventually end in protected-closed.	Next 20 years: experiment with islands. Can be done in steps but this limits effectivity. Afterwards difficult to change. This category can be triggered because of socio-economic or international developments.	Next 20 years: change in new construction, experiments with different land use. Limited possibilities for heightening land/buildings. Difficult to stimulate with low awareness. Can be triggered because of floodings or lack of trust in government.

Besides the height of sea level rise, another limiting factor for the solution directions is the speed of sea level rise. Soft measures, such as sand replenishment can maximally increase the height of the land by 1cm per year. Areas which are frequently flooded (marshes) can potentially have a higher speed of heightening the land.

Protect can probably be implemented the soonest, Seaward and Move along will likely take more time.

A1.4 A combination of the solution directions for Rotterdam

A team of 'Resilient Delta' (De Urbanisten, LOLA (LOst LAndscapes), & Royal Haskoning DHV, 2022). has made a vision for the city of Rotterdam with 2-3 meters of sea level rise. They had to envision a future where life, work and recreation can be safe and sustainable. They propose a protective strategy in which the city gets a closed freshwater cycle. They see the city as a sponge where water can be stored, collected and used. This contributes to the resilience of the landscape including the quality of the living environment and biodiversity. Figure 24 and 7 illustrate how they visualize this future sponge city.

Figure 24 Impression of Rotterdam in 2200

Figure 25 Impression of the future port in 2200

Besides these visualisations, they also provided some measures with which this can be accomplished. These can be seen in Figure 26. They propose to close dike ring 14 so there is high water protection from the coast towards the Utrechtse Heuvelrug. They also propose to close the centre of the New Meuse river to create a freshwater core within the city's water system. This creates the possibility for more housing in the city as there will no longer be tide within the city centre. The New Meuse will thus be closed off for commercial shipping. Furthermore, they make the polders around the city wetter so they can better cope with floods and droughts. With these measures, Rotterdam should be protected against the higher sea level and also be able to deal with dry and wet periods.

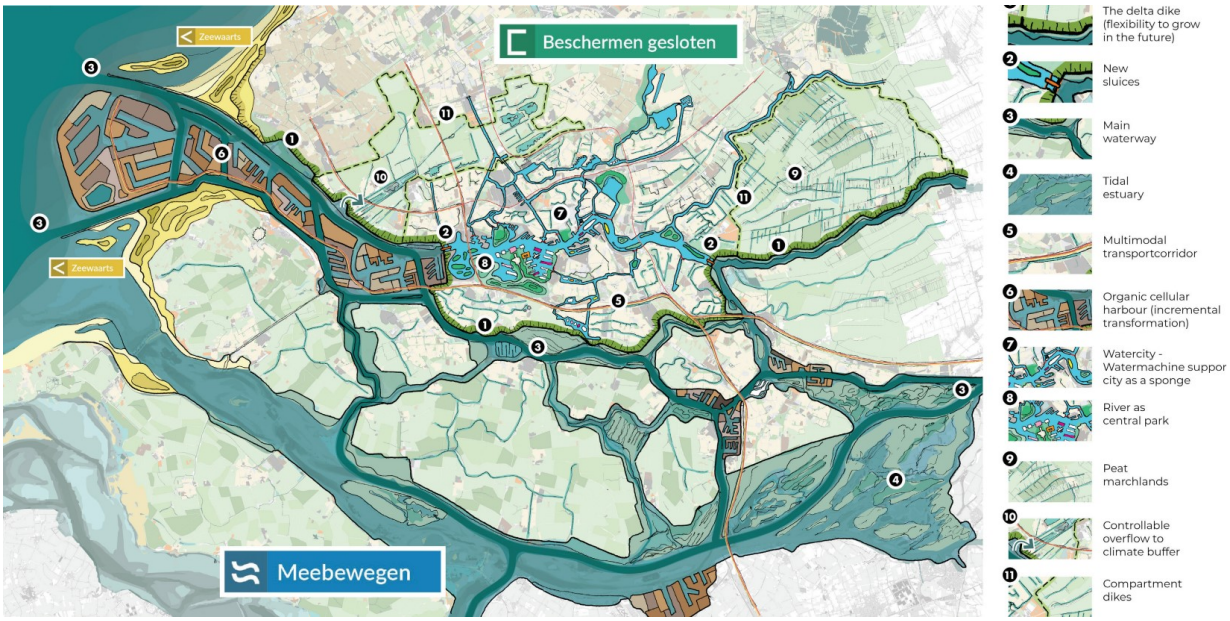


Figure 26 Potential measures Rotterdam 2200

A2. Interview questions

The interview questions are both written down in English and in Dutch. As all interviews will be conducted in Dutch and the explanation of the measures are already in English in this report, the explanations of the methods in this Appendix will only be in Dutch.

A2.1 English interview questions

A2.1.1 Section 1 – Consent forms:

- For me (interviewer) explain the following points to the interviewee
    - This interview is conducted for my master thesis at the TU Delft.
    - Topic: attitudes to different solutions to sea level rise
    - It will take around 45 minutes
    - Types of questions: first some questions related to sea level rise will be asked, then questions related to the possible adaptation measures will be asked
    - This interview is voluntary and you can decide not to answer a questions or stop the interview at any time
    - I will be recording the audio of the interview so I can type it out at home, I will immediately delete the recording after I have written it out.
    - You can request your data to be removed up to three weeks after this interview
- Do you have any questions? Can you fill out this consent sheet?

A2.1.2 Section 2 – [S2] how do citizens perceive the problem of sea level rise:

- Do you know what sea level rise means?
- Do you know how much the sea level will rise and what this means for Rotterdam?
- Are you concerned with sea level rise in day-to-day life?
- Do you have any experience with (the threat of) flooding?
- Do you know of any possible measures that could help reduce the threat of flooding?

A2.1.3 Section 3 – [S3/S4] Questions on possible adaptation measures:

- There are four possible extremes for how to deal with sea level rise. First I will explain these possible solutions and ask you what you think about them. Then I will show a possible method for which to combine the methods and what you think about that one. One important thing to keep in mind is that if you don't like any of them and would prefer the government not to implement any, there is a higher risk of flooding as there is no defence against sea level rise.
- Explanation of four measures: see Section A1.2 of this report or the Dutch version.
- What do you think about these measures?
    - Could you rank each measure with a grade between 1 and 10?
    - What are your reasons for the rankings?
    - Do you think it will be effective?
    - Do you think the benefit-cost ratio is okay?

- Explanation of combined method: see Section A1.4 in this report or the Dutch version.
- What do you think of this combined method?
    - Could you rank it with a grade between 1 and 10?
    - What are your reasons for the rankings?
    - Do you think it will be effective?
    - Do you think the benefit-cost ratio is okay?

- Are you happy with your grades or do you want to change them?

- Are there any methods that are totally not acceptable for you? And why not?
- If you had to choose one of these methods, which would you choose?
- Do you think that more options should be explored? If yes, do you have anything in mind?
- Are there considerations that aren't reflected here that are important to you?

A2.1.4 Section 4 – Questions to reduce bias/to check influence of others:

- If you think from the perspective of your grandchildren, do you think they would make the same choices?
- Did you know about any of these potential solutions before this interview? If yes, where did you hear them?

A2.1.5 Section 5 – General questions participant:

- For interviewer: The next questions can be sensitive so I want to emphasize that you do not have to answer any of the questions if you do not want to. The questions are mainly meant so I know if I have a representative image of the citizens of Rotterdam. If you do not want to answer the questions, the remainder of the interview is still very useful for me.
- As what gender do you identify?
- What age are you?
- Which ethnicity are you?
- What level of education do you have?
- What kind of work/study do you do or have you done?
- Do you have children?
- How long have you lived in Rotterdam?
- Where in Rotterdam do you live?
- What is your political view? For which political party do you vote/where on the political spectrum are you?

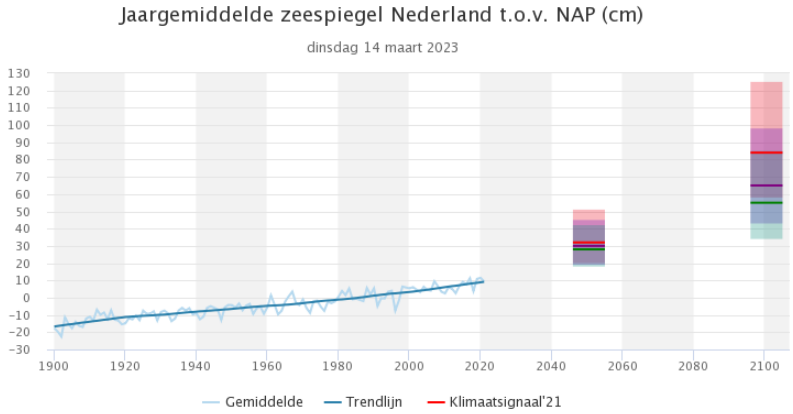
A2.2 Dutch version interview questions

A2.2.1 Onderdeel 1 – toestemmingsformulier

- Als interviewer, leg de volgende punten uit:
    - Dit interview zal gebruikt worden voor mijn master scriptie aan de TU Delft
    - Het onderwerp is houdingen van mensen in Rotterdam tegenover verschillende mogelijke oplossingen voor zeespiegelstijging
    - Dit interview duurt ongeveer 45 minuten
    - Verschillende soorten vragen zullen gesteld worden. Eerst worden wat algemene vragen over zeespiegelstijging gesteld, hierna zullen we echt naar de mogelijke oplossingen gaan kijken.
    - Dit interview is vrijwillig en u mag op elk moment stoppen of besluiten dat u een vraag niet wilt beantwoorden.
    - Het geluid van het interview wordt opgenomen zodat ik het thuis uit kan typen, ik zal de opname meteen verwijderen zodra ik het heb uitgetypt.
    - Uw data kan tot drie weken na het interview verwijdert worden, als u dit wilt kunt u contact opnemen via de mail
- Heeft u nog vragen? Zou u de consent form in willen vullen.

A2.2.2 Onderdeel 2 – vragen zeespiegelstijging

- Weet u wat zeespiegelstijging inhoudt?
- Weet u hoeveel de zeespiegel zal stijgen en wat dit betekend voor Rotterdam? (zie grafiek voor cijfers)
    - Voor 2050 zal het ten opzichte van 1980 zo rond de 20 en 50cm zeespiegelstijging zijn. Bij 2100 zijn de verschillen groter aangezien dat ook nog meer afhankelijk is van de emissieuitstoot. Dan zal het tussen de 35cm en 125 cm liggen. Ander onderzoek wat verwacht dat de ijskappen bij Antarctica sneller zullen smelten verwacht zelfs dat het in 2100 tot 292cm kan stijgen.
    - Voor dit onderzoek kijk ik vooral naar de extreme gevallen dus hou hier in de oplossingsrichtingen ook rekening mee.
- Bent u bezorgd over zeespiegelstijging in het dagelijkse leven?
- Heeft u ervaring met (de dreiging van) overstromingen?
- Weet u mogelijke maatregelen om de dreiging van overstromingen te verminderen?



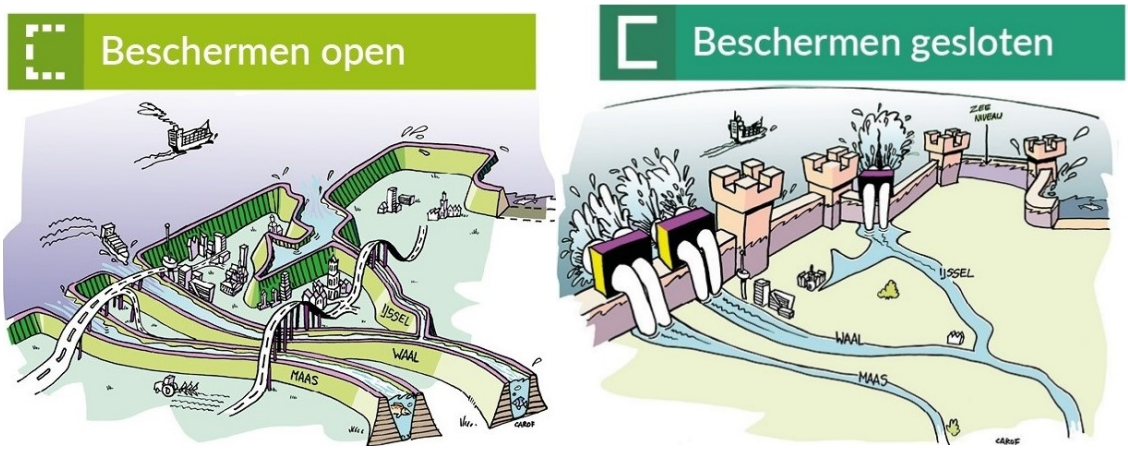
Andere zegt 292cm in 2100 (versnelde smelting Antarctica)

A2.2.3 Onderdeel 3 – Mogelijke oplossingen

De oplossingen voor zeespiegelstijging kunnen ondergebracht worden in vier categorieën. Twee van deze zijn samengevoegd aangezien ze voor zeer hoge zeespiegelstijging in een oplossing resulteren. Ik zal de richtingen een voor een uitleggen en er wat vragen over stellen. Een belangrijk aspect om in uw achterhoofd te houden is dat het alternatief van geen van deze maatregelen kiezen is dat de overheid niks doet en dat er dus een hoog risico op overstromen is.

Beschermen

Dit is de richting die eigenlijk uit twee categorieën bestaat. Ik heb ze samengevoegd aangezien beschermen open bij hogere mate van zeespiegelstijging niet meer mogelijk is en dus lijdt tot beschermen gesloten. Hier ziet u visualisaties van deze oplossingsrichtingen.



Beschermen betekend dat het huidige land beschermt wordt tegen zeespiegelstijging. Dit kan op verschillende manieren gebeuren. Voorbeelden zijn hogere of extra dijken, duinen en stormvloedkeringen. Bij beschermen open blijven de rivieren in open verbinding met de zee. Dit zorgt ervoor dat scheepsvaart door kan gaan. Bij hogere zeespiegelstijging zullen stormvloedkeringen vaker en vaker dicht gaan waardoor het uiteindelijk niet meer haalbaar is om ze open te doen. Hierdoor eindigt deze maatregel uiteindelijk in beschermen gesloten. Hierbij zijn de rivieren niet meer in open verbinding met de zee maar zijn ze volledig afgesloten of alleen verbonden via een sluis.

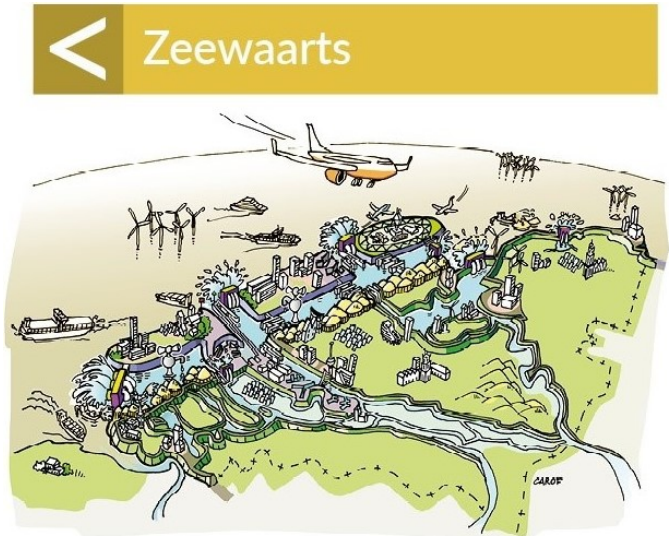
Bij deze oplossingsrichting zullen hogere en dus ook bredere rivierdijken nodig zijn. Bij beschermen open is dit omdat het water in de rivieren hoger zal staan aangezien dit meestijgt met de zeespiegelstijging. Bij beschermen gesloten is dit omdat rivierwater afgevoerd moet kunnen worden naar de zee, hiervoor is ook een hoge pompcapaciteit nodig omdat water omhoog gepompt moet worden. Het is op sommige plekken lastig om de dijken te verhogen/verbreden aangezien er niet voldoende ruimte is. De verbrede dijken kunnen echter eventueel ook gebruikt worden voor andere dingen dan alleen het water tegenhouden, zoals recreatie of het bouwen van huizen.

Op het gebied van de natuur zal bij beschermen open de zoutindringing heviger zijn en zal het zout verder landinwaarts komen. Dit kan gevolgen hebben voor de landbouw en de zoetwatervoorziening. Wel zullen ecologische gebieden grotendeels in stand gehouden kunnen worden. Beschermen gesloten zorgt ervoor dat zoutindringing minder ver kan komen. De natuur zal echter wel hevige gevolgen ondervinden aangezien getijden gebieden afgesloten zullen worden.

- Wat denkt u over deze oplossingsrichting?
    - Kunt u het een cijfer tussen de 1 en de 10 geven?
    - Waarom heeft u voor dat cijfer gekozen?
    - Denkt u dat deze richting nuttig/effectief zal zijn om ons te beschermen tegen zeespiegelstijging?
    - Denkt u dat de kosten – baten verhouding oké is?

Zeewaarts

Hier ziet u de afbeelding voor zeewaarts.



Zeewaarts houdt in dat er nieuw, hoger en zeewaarts land gebouwd zal worden om de Delta te beschermen tegen overstromingen. Dit land zal ook gebruikt kunnen worden voor andere dingen zoals huizen, natuur, recreatie, transport, etc. Een voorbeeld van hoe dit eruit kan komen te zien is om een nieuw stuk land te maken wat als het ware een meer creëert tussen het nieuwe land en de huidige kust. Een ander voorbeeld is om bijvoorbeeld eilanden te maken die fungeren als golfbrekers en zo ervoor zorgen dat de kust minder snel afbreekt.

De huidige kust zal dus beschermt worden door een nieuwe ring van dijken of eilanden, maar zal nog wel onderhouden moeten worden. Zoutindringing en kwel (water wat onder de dijk doorsijpelt en omhoog komt) kan voorkomen maar zal sterk beperkt zijn tot de kustgebieden. Rivier water zal naar de zee moeten worden gepompt bij een overschot aan water, een kustmeer kan ruimte voor tijdelijke opslag bieden. Voor het wegpompen van het water is redelijk wat pompcapaciteit nodig.

Verder is er ook een enorme hoeveelheid zand nodig om de nieuwe gebieden te bouwen. Het is nog onduidelijk hoeveel zand er te verkrijgen is maar het is al wel duidelijk dat de methode en bekostiging van zandsuppletie aangepast zal moeten worden.

Deze oplossingsrichting heeft een grote invloed op de natuur in de Noordzee aangezien er veel zand wordt verplaatst en dit dus het habitat kan verstoren.

- Wat denkt u over deze oplossingsrichting?
    - Kunt u het een cijfer tussen de 1 en de 10 geven?
    - Waarom heeft u voor dat cijfer gekozen?
    - Denkt u dat deze richting nuttig/effectief zal zijn om ons te beschermen tegen zeespiegelstijging?
    - Denkt u dat de kosten – baten verhouding oké is?

Meebewegen

Meebewegen betekend dat je de kwetsbaarheid tegen zeespiegelstijging vermindert door bijvoorbeeld zouttolerante landbouw, het verhogen van land, andere ruimtelijke ordening of migratie.

Iets wat past binnen deze richting is bijvoorbeeld het bouwen van huizen op palen of terpen. Het is ook mogelijk om megaterpen te maken waar meerdere gebouwen op kunnen staan. Een nadeel aan terpen is dat ze lastig aan te passen zijn aan hogere zeespiegelstijging aangezien wanneer er een gebouw opstaat, hij moeilijk verder opgehoogd kan worden. Een flexibelere methode is om drijvende eilanden, steden of huizen te maken.

Het zal erg lastig zijn om bestaande bebouwde gebieden op te hogen door de bestaande voorzieningen die daar al staan. Het is wel mogelijk om nieuwe wijken hoger te bouwen. Verder zijn er nieuwe technologieën mogelijk om drijvende steden te creëren of bestaande gebieden op te hogen. Voor de natuur is deze oplossingsrichting relatief positief aangezien de natuur meer ruimte krijgt.

Een andere optie is om te migreren naar hoger gelegen delen van het land. Hierbij zal het vooral lastig zijn om mensen te overtuigen en om alle bestaande bebouwing opnieuw te bouwen in een andere locatie.

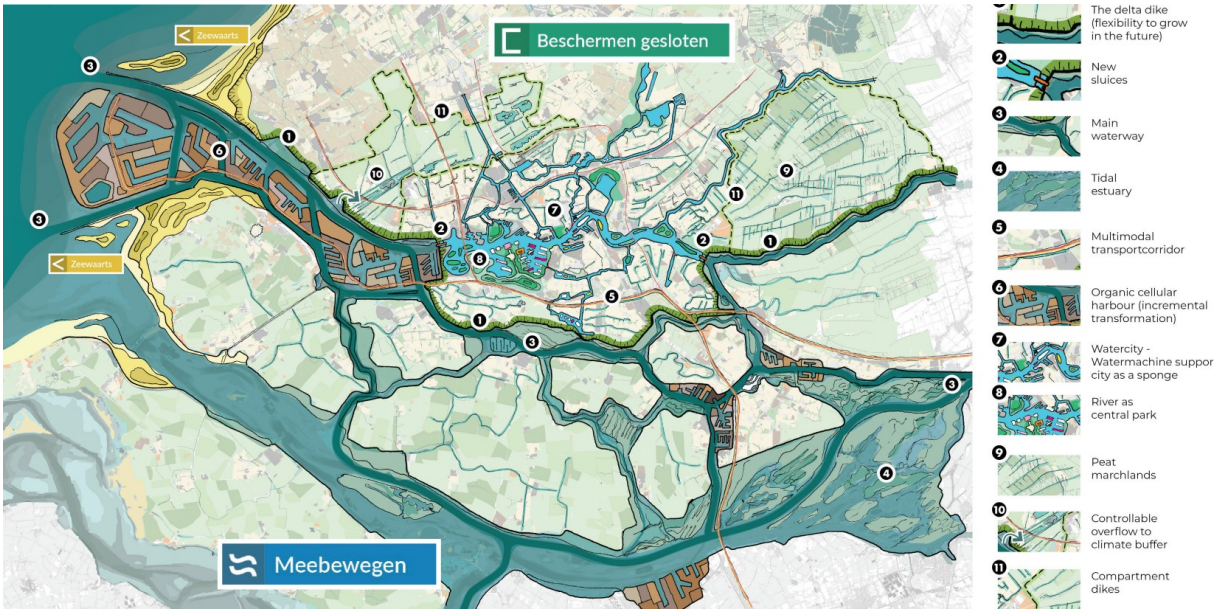
- Wat denkt u over deze oplossingsrichting?
    - Kunt u het een cijfer tussen de 1 en de 10 geven?
    - Waarom heeft u voor dat cijfer gekozen?
    - Denkt u dat deze richting nuttig/effectief zal zijn om ons te beschermen tegen zeespiegelstijging?
    - Denkt u dat de kosten – baten verhouding oké is?

Algemene vragen drie richtingen

- Bent u nog tevreden met de cijfers of wilt u ze veranderen?
- Is er een methode die totaal niet acceptabel is voor u? Waarom niet?
- Als u een van deze opties moest kiezen, welke zou u dan kiezen?

Gecombineerde methode

We hebben nu dus elke richting apart besproken. Maar het is onwaarschijnlijk dat er volledig voor een van deze richtingen gekozen zal worden. Een groep heeft een visie gemaakt voor Rotterdam bij 2-3 meter zeespiegelstijging. Hierbij combineren ze de verschillende richtingen. Hieronder is een afbeelding te zien van wat zij voor ogen hebben.



Het idee is dat aan de kust zeewaarts extra gebied gecreëerd zal worden wat het land beschermt. Verder zal de maas afgesloten worden wat valt binnen beschermen gesloten. Dit wordt gedaan door sluizen te plaatsen aan de randen van het centrum (2). Hierdoor kan vrachttransport niet meer over de Nieuwe Maas en zal dit of via de Oude Maas of via het Hollands Diep moeten gaan (3). De andere aspecten die binnen beschermen passen is dat er extra dijken worden geplaatst of bestaande dijken worden verstevigd (1)(11). Bij het Hollands Diep en de Biesbosch zal er meer ruimte voor het water komen en het getijden gebied zal meer ruimte krijgen (4). Ook is er een gebied wat gecontroleerd overstroomd zal worden om als buffer te dienen (10). Ten slotte zijn er turf en moeraslanden in een deel van de polder (9).

- Wat denkt u over deze gecombineerde methode?
    - Kunt u het een cijfer tussen de 1 en de 10 geven?
    - Waarom heeft u voor dat cijfer gekozen?
    - Denkt u dat deze richting nuttig/effectief zal zijn om ons te beschermen tegen zeespiegelstijging?
    - Denkt u dat de kosten – baten verhouding oké is?

Algemene vragen oplossingen

- We hebben nu elke oplossingsrichting bekeken, denkt u dat er meerdere opties bekeken moeten worden of denkt u dat er voldoende opties zijn? Als u denkt dat er meer bekeken moet worden, heeft u iets in gedachte?
- Zijn er bepaalde dingen hier die voor uw gevoel niet meegenomen worden maar dat wel zouden moeten?

A2.2.4 Onderdeel 4 – Vooroordeel weghalen

- Beeld u in dat u uw kleinkind bent. Denkt u dat zij dezelfde keuze zouden maken?

- Kende u een van deze mogelijke oplossingen al voor dit interview? Zo ja, waar heeft u hierover gehoord?

A2.2.5 Onderdeel 5 – algemene vragen

De volgende vragen kunnen gevoelig zijn dus ik wil graag nogmaals duidelijk maken dat u de vragen niet hoeft te beantwoorden als u dat niet wilt. Deze vragen zijn vooral zodat ik weet of ik een representatief beeld heb van de inwoners van Rotterdam. En dat ik weet of ik een diverse groep mensen interview. De rest van het interview is nog steeds erg nuttig voor mij als deze vragen niet beantwoord worden.

- Als welk geslacht identificeert u zich?
- Hoe oud bent u?
- Wat is uw etniciteit?
- Wat is uw opleidingsniveau?
- Wat voor soort werk/opleiding doet u of heeft u gedaan?
- Heeft u kinderen?
- Hoe lang woont u al in Rotterdam?
- Waar in Rotterdam woont u?
- Wat is uw politieke mening? Voor welke partij stemt u/ waar op het politieke spectrum bevindt u zich?

Als laatste vraag, kent u misschien andere mensen die geïnteresseerd zouden zijn om mee te helpen aan dit onderzoek?

Heel erg bedankt voor uw tijd en hulp.

A3. Informed consent materials

Opening statement interviews

You are being invited to participate in a research study titled 'attitudes on solution directions for sea level rise'. This study is being done by Anne van Avendonk from the TU Delft.

The purpose of this research study is to assess the attitudes of citizens in the municipality of Rotterdam on possible solution directions to sea level rise. The data will be used to write my master thesis, this thesis will also be published on the network of the TU Delft so other students and professors can read it. We will be asking you to provide your opinion on sea level rise and on the different possible solutions to sea level rise. This interview will be audio-recorded so it can be written down later. As soon as it has been written down, the audio will be deleted.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by pseudonymizing and thus not mentioning your name in the transcribed interview and by processing the data which makes it more difficult to see who mentioned which opinions. The unprocessed interviews will also be deleted as soon as they are no longer needed for the research. Furthermore, no one besides me and my supervisors are able to hear and read the unprocessed interviews.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. You can also request your data to be removed up to three weeks after the interview has been conducted. At a later date the removal of the data will be difficult as it has already been processed.

For questions after this interview, my contact details are:

Name: Anne van Avendonk

Do you have any questions regarding these aspects? If not we will start the interview.

Please tick the appropriate boxes	Yes	No
1. I have read and understood the interview information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: An audio-recorded interview where the audio will be removed as soon as it has been written down.	☐	☐
4. I understand that taking part in the study involves collecting personally identifiable research data (PIRD) (personal opinions) which create a risk of my identity being revealed	☐	☐
5. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: pseudonymising data, secure data storage with limited access, transcription and deleting of audio records	☐	☐
6. I understand that personal information collected about me that can identify me, such as the specific organisation in which you are involved, will not be shared beyond the study team.	☐	☐
7. I understand that the (identifiable) personal data I provide will be destroyed at the end of the research project (July 2023)	☐	☐
8. I understand that after the research study the de-identified information I provide will be used for the master thesis which will be published on the TU Delft network	☐	☐
9. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐
10. I give permission for the de-identified, processed data that I provide to be archived in the repository of the TU Delft, which is only accessible to students and employees of the TU Delft, so it can be used for future research and learning	☐	☐

SIGNATURES

Name of participant Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Anne van Avendonk

Researcher name Signature Date

Contact details: Anne van Avendon

Toestemmingsformulier - Nederlands

Vink de juiste vakjes aan	Ja	Nee
1. De interviewinformatie is aan mij voorgelezen en deze heb ik begrepen. Ik heb vragen kunnen stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐	☐
2. Ik stem er vrijwillig mee in om deel te nemen aan dit onderzoek en begrijp dat ik kan weigeren vragen te beantwoorden en dat ik me op elk moment kan terugtrekken uit het onderzoek, zonder dat ik hiervoor een reden hoef op te geven.	☐	☐
3. Ik begrijp dat deelname aan het onderzoek inhoudt dat de audio wordt opgenomen en dat deze wordt verwijderd zodra het is uitgetypt.	☐	☐
4. Ik begrijp dat deelname aan het onderzoek het verzamelen van persoonlijk identificeerbare onderzoeksgegevens (PIRD) (persoonlijke meningen) met zich meebrengt, waardoor het risico ontstaat dat mijn identiteit wordt onthuld	☐	☐
5. Ik begrijp dat de volgende stappen zullen worden genomen om de dreiging van een datalek tot een minimum te beperken en mijn identiteit te beschermen in het geval van een dergelijk datalek: pseudonimisering van gegevens, veilige gegevensopslag met beperkte toegang, transcriptie en verwijdering van audio-opnamen	☐	☐
6. Ik begrijp dat persoonlijke informatie die over mij is verzameld en die mij kan identificeren, zoals de specifieke organisatie waarbij u betrokken bent, niet buiten het onderzoeksteam zal worden gedeeld.	☐	☐
7. Ik begrijp dat de (identificeerbare) persoonsgegevens die ik verstrek aan het einde van het onderzoeksproject (juli 2023) zullen worden vernietigd	☐	☐
8. Ik begrijp dat de geanonimiseerde informatie die ik verstrek na het onderzoek zal worden gebruikt voor de masterscriptie die zal worden gepubliceerd op het TU Delft-netwerk	☐	☐
9. Ik ga ermee akkoord dat mijn antwoorden, standpunten of andere input anoniem kunnen worden geciteerd in onderzoeksresultaten	☐	☐
10. Ik geef toestemming dat de geanonimiseerde, verwerkte gegevens die ik aanlever, worden gearchiveerd in de repository van de TU Delft, zodat deze kunnen worden gebruikt voor toekomstig onderzoek.	☐	☐

Handtekeningen

Naam van deelnemer Handtekening Datum

Ik, als onderzoeker, heb de informatie nauwkeurig gelezen aan de potentiële deelnemer en heb er naar mijn beste vermogen voor gezorgd dat de deelnemer begrijpt waar hij/zij vrijwillig mee instemt.

Anne van Avendonk

Naam onderzoeker Handtekening Datum

Contactgegevens: Anne van Avendonk