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Living with Water

Building on water for safety in regard to climate change

Details

Title:

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Subtitle:

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Preface

Before you lies my bachelor thesis “Living with Water”. It has taken some effort and many more hours, but I hope it will be a good read for you.

In this endeavor, I have had help from different persons, who all deserve my thanks. In the first place Jacco Kuper, my supervisor from the university; he helped me throughout my thesis by steering me in the right direction when slightly lost.

Furthermore, I want to thank all persons willing to take their time for an interview: M. Beerthuizen, I. De Jong, A. Laane and P. Otten. Their insight has been highly helpful and interesting.

Lastly, everyone prepared to give me tips and tricks that have led to this product have my gratitude. I hope all who read it will enjoy it.

Abstract

With the rise of the ocean level and increase in the peak discharge of rivers due to climate change, the Netherlands, a country with a sizable area beneath sea level, will have to evaluate its flood risk management approach (deltaprogramma, 2014). A possible solution for this problem is the strengthening of the dikes, though other measures exist to minimize damage and casualties from flooding. One of this measures is the realization of floating houses (Van Vliet and Aerts, 2014). This has not been attempted in the Netherlands as a flood risk management measure. In this paper, the central question researched is: “What is the feasibility of the realization of floating homes as adaptive flood risk management strategy?” This was done by conducting a series of interviews with project leaders for various projects involving floating houses and inhabitants of a finished project in Amsterdam.

From this research, it can be concluded that all technical problems with floating homes regarding water level differences can be solved, though no data about extreme differences could be collected due to the nature of the existing projects. The houses are generally seen as an addition to spatial quality or a way to use living on the water as a quality of a home. For now, floating homes are too expensive to realize as social rent, though cheaper housing is possible when a neighborhood has a high density. Another conclusion from the research is that floating homes may be a feasible solution to other spatial questions, such as optimizing the drainage of rainwater in urban areas.

Contents

1 Introduction

Background

It is well known that the Netherlands have always been combating water in one way or another, due to the fact that a substantial portion of the country lies beneath sea level (figure 1). However, due to climate chance and the predicted rise of the sea level, structural defenses alone may not suffice. In the city of Rotterdam, for example, there are neighborhoods that are unprotected against flooding: their only defense is a somewhat elevated position relative to sea level. According to Van Vliet and Aerts (2014), the Dutch are starting to experiment with adaptive flood protection, though the legal standards and framework are not yet modified to adaptive flood defense yet. A few examples are the floating homes being built in Rotterdam, currently innovating with building climate adaptive at the moment, due to its prime location around the river Meuse. Another measure the city has executed are the construction of a water square, which functions as a playground when not storing excess rainwater.

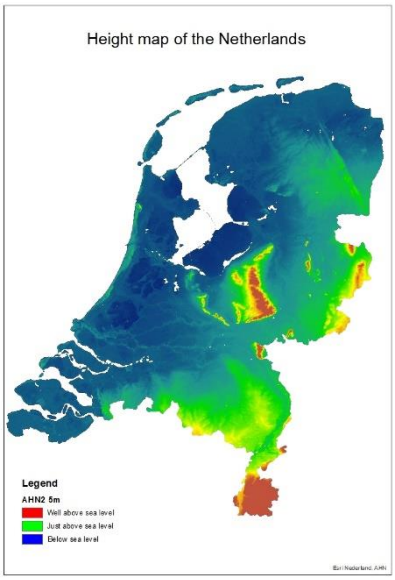

Figure 1: Height map of the Netherlands (Author)

1.1 Research problem

The Dutch government has defined floating homes as “Floating building as defined by the Housing Law”. The house qualifies as a building when it is fixated horizontally, though vertical movement is allowed. Because of the relative novelty of these floating houses, little research about these projects has been conducted. This does not mean that the architects, contractors, and municipalities have not thought about the needs of these new floating neighborhoods.

With the conducting of a study, a theoretical framework for the planning of floating houses was created. The research question is as follows: “What is the feasibility of the realization of floating homes as adaptive flood risk management strategy?” To answer the research question, different sub questions need answering. First, the conditions for building floating houses need to be set. Floating homes are part of the “Housing Law”, Dutch legislation for standards in buildings. The question to be answered here is: “What are the spatial and technical requirements for the realization of floating homes?”

Parallel to this, building a group of these kind of homes need to fit in the cities policies. According to Dutch law, new projects need to fit into the “Bestemmingsplan”, or zoning plan. This plan can be changed by the municipality to allow for building when necessary or desirable, allowing for directions given by higher governments. Also, parallel governments need to be taken into account, for example the Water boards. There may be more factors that have desires in relation to a new neighborhood. For a proper answer to the feasibility, the second part of the research must answer the following question: “What are the desires of the stakeholders in a floating neighborhood?”

Finally, to ensure the success of a neighborhood, it must be attractive. For this it is necessary for the possible inhabitants to enjoy it. The final question to answer will therefore be: “What are the experiences of the current users of floating homes?”

2 Theory

In literature, much has been written on flood risk management. However, it rarely relates directly to floating homes. This is partly the aim of this study to find out, so that floating houses may become easier to implement as a measure in the future. In the following chapter the established theories surrounding flood risk management and floating houses will be discussed.

2.1 Climate change

One of the reasons of the growing importance of water management is the effect of climate change on the behavior of water systems. Stocker et al. (2013) concluded that sea levels will continue to rise due to climate change. They also conclude that precipitation will increase yearly. This increase will be even larger in regions with a higher latitude. Also, the heavy rain events will be more intense, meaning more rain falling in the same amount of time.

2.2 Flood risk Management

The increase of the sea level and rainfall intensity can be a problem for the Netherlands, since it largely lies below sea level. This means that the Dutch already have flood defense against the sea in place, and have a tradition in water management. For flood defense, the Dutch approach to flood risk management used to consist of a cost-benefit based approach, where, simply put the cost of a dyke should not be larger than the damage it was preventing. The focus shifted to a risk-based approach with more emphasis on the consequences of eventual flooding. In the new model, the consequences consist of damage and casualties. (Van Alphen, 2013) This new model is shown in figure 2.

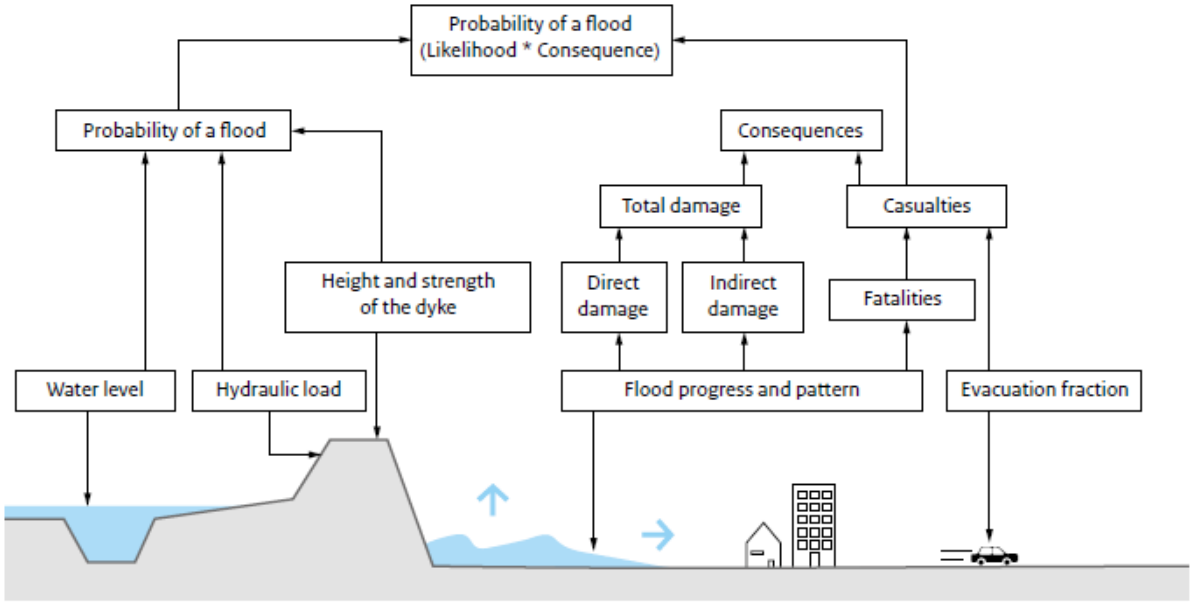

Figure 2: new Risk-based approach (Van Alphen, 2013)

The risk-based approach uses the risk of a flood, which is a function of both probability on one side, and consequences on the other. The probability can be reduced using so-called “hard measures”. These consist for example of dikes, dams, and sluices. The other side, consequences, consists of the damage to both persons, and buildings and belongings. Measures that aim to decrease this side are called “soft measures”. These can consist of anything from a better evacuation regime to making buildings more water resistant. (Van Alphen, 2013)

This model is subscribed by Hung et Al. (2016) in a more abstract form. Hung et Al. argue that the capacity to adapt to a hazard is made up primarily from the capacity of coping responses and the learning- and adaptation ability. Adaptation is defined by Butler et Al.(2017) as "targeted actions or adjustments carried out in a specific system in response to actual or anticipated threats in order to minimize failure consequences". These factors are directly relatable to the dampening of the consequences in case of flooding. Through this definition, soft measures are also called "adaptive measures".

Butler et Al. (2017) conclude that traditional "fail-safe" water management, focusing solely on hard measures to prevent flooding, creates a false sense of security. Instead, measures that focus on prevention should be adding a "Fail-to-safe" layer, which focuses on adaptation and coping. Not all sources, however, agree that hard measures are not sustainable. Stijnen et al. (2012) have concluded that for flooding, the current Dutch model of creating "Polders" is technically and financially sustainable. This is under the condition that all dikes are updated to standard. At the moment, all dykes are being evaluated, though this evaluation round is not finished. The Netherlands are working at the moment to get the hard defenses up to standard. Currently, 555 kilometer of dykes have been evaluated, 135 kilometer are being evaluated and 2.757 kilometer are still scheduled for evaluation (Deltaprogramma Deltacommissaris, 2018).

The contradiction in these findings can be settled with the findings of Priemus (2017), who finds that, with the Delta program in mind, there should be an added focus on synergy between flood protection, infrastructure, and spatial planning. From this can be concluded that the hard defenses can be sustainable, though people must be kept aware of flood risks, just as planning needs to integrate flood risk. One way to do both is the realization of floating homes, for they are residential areas that second as water storage, and people living in them could be more aware of the water.

2.3 Criteria for successful flood risk management

To make sure that a measure is successful in reducing flood risk, it must fulfill certain criteria. Fornier et Al. (2016) researched the relation between governance and flood risk mitigation. They have set five criteria for successful flood risk measures. First, a good multi-level government. For the creation of floating houses, the main necessity of multi-level government is the cooperation from provincial and national government. These can give directions to the municipal government, which plans the floating houses. Secondly: participation from citizens. For any project to be successful, citizens living around or in the project must agree with its design. Third criterion is flexibility in government arrangements. Building on water is a relative novelty, which means that policies must be able to facilitate these projects. Fourth is the usage of the appropriate scale for problems. This is part of the main question. Can floating houses mitigate flood risk, or is the problem too big for this solution? The last criterion is opportunities for experimentation and learning. (Fornier et Al; 2016) The Netherlands are rated as highly developed in the area of adaptive governance in flood risk management by Fornier et Al. (2016) Especially flexibility is rated "High" when it comes to local solutions. This should create the opportunity for municipalities to implement measures such as floating housing.

Voogd (2006) researched different parts of flood risk management by identifying key factors from the Dutch water management practice. These factors consist of public participation, public awareness, the fulfillment of the Water Assessment Test as a framework for new plans, and the planning for space for water. These practices explain the good scoring on multilevel governance by Fournier et Al. (2016). Van Vliet & Aerts (2014) also state that public awareness is important for support for adaptive measures, and state that communication is key in this issue.

2.4 Alternative adaptive measures

Next to floating houses, different soft measures can be taken. Here, their position relative to floating houses shall be discussed. Van Vliet and Aerts (2014) mention the wet- and dry-proofing buildings. The former is a measure where the part of a building prone to flooding is designed and decorated for minimum function loss and value loss when flooded. Dry-proofing involves making a building water resistant up to a level where the flood risk is acceptable. As an adaptive measure in flood risk management, floating housing has the benefit over dry-, or wet proofing buildings, because, according to De Moel et al. (2013) and Van Vliet and Aerts (2014), the municipalities cannot force contractors to dry-, or wet proof buildings, though they can set out a tender for floating buildings. Adding to this is that floating houses have less Expected Annual Damage than the other adaptive measures. (De Moel et. Al; 2014) This means that floating houses should be a more effective measure.

2.5 Attractiveness and demand

As mentioned before, public participation is an criterion for a successful flood risk management project, including floating houses. To make sure that civilians want to live in the floating houses, attractiveness of the homes is a factor. For this attractiveness to possible residents, Daams et al. (2016) have researched the added value by Perceived Attractiveness of different natural areas. They concluded that the housing prices received a premium from the proximity of these PA areas, indicating an increased demand. These areas may consist of different terrain types, though they mostly are a mixture of different types. Some of these areas consist of coastal and inland waters, and open wet nature. Some of these qualities will always be present in a group of floating homes, although not all of this nature is always perceived attractive. Shaping of the surroundings in the project may be necessary to create this added desirability. Proximity to the water can thus create added attractiveness to possible residents.

Rijcken (2006) relates floating housing of all kinds with classical values: Costs, bohemia, manipulating legislature, and mobility. Rijcken stresses that people historically are drawn to borders between water and land, not to living on water. For attractiveness in floating homes as defined in this research, especially costs and bohemia, a sense of living apart with nature, are important factors. This is because the floating homes are immobile and being built by plans of municipal governments. Pasternack (2009) also finds that feeling a connection with nature is a common attraction of floating housing.

2.6 Factors for feasibility of floating houses

As seen before, there are multiple factors that weigh in for the success of floating houses as flood risk management measure. These factors can be divided in different groups. Attraction is a factor that affect people's desire to use the floating houses as houses. When nobody wants to do this, the efficiency of the measure decreases, making other measures relatively more feasible. If the measure is attractive, demand for the houses will be bigger, making the measure more feasible. The area where the measure can be implemented needs to be suitable for it as well. Different factors may weigh in in this restriction. These will be researched in this dissertation, but it may for example consist of a minimum water depth or transport systems nearby. Also, floating houses must be technically possible, this may differ per location, but if floating houses are too difficult to engineer, this may affect the feasibility as a flood risk measure. Policy is the last of the factors for a successful measure. This means that rules and regulations should allow for floating houses. This factor can also have an indirect impact on the other factors, through the design of the houses themselves. Such as technical feasibility and attractiveness. The relation between all these factors are shown in the conceptual model (figure 3).

2.7 Conceptual model

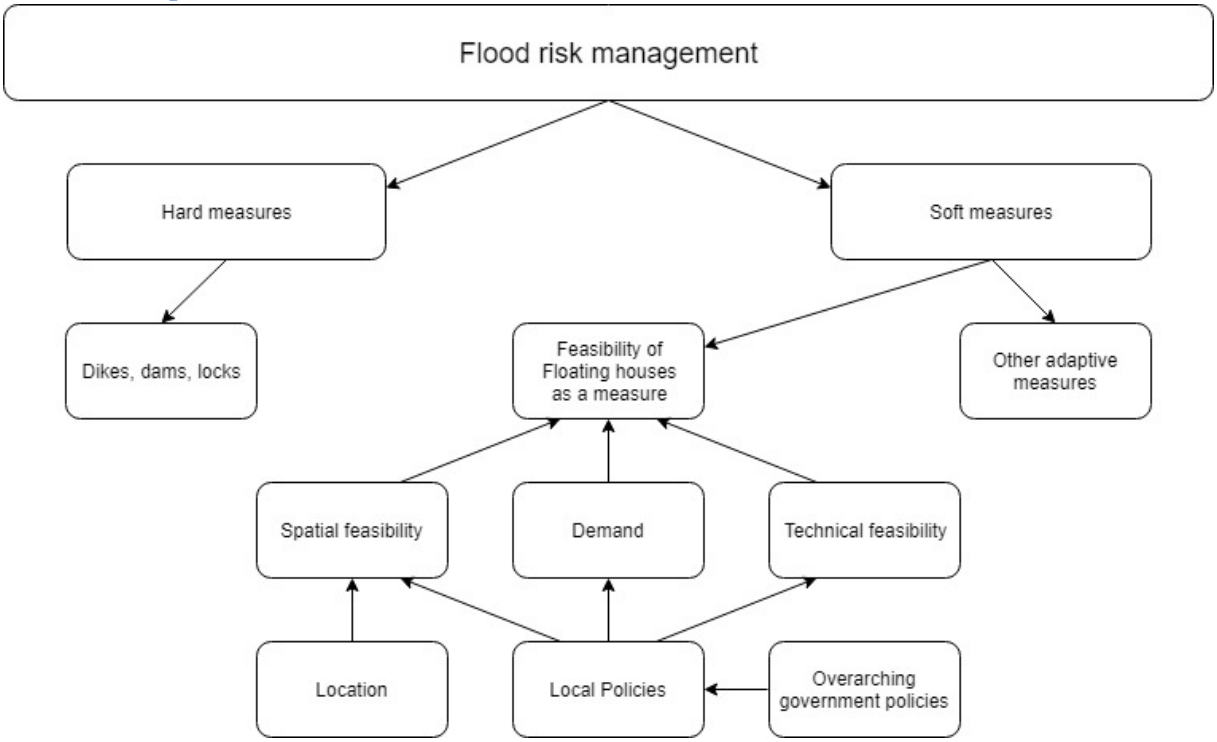

Figure 3: Conceptual Model

Flood risk management can be divided in two sides, hard measures and soft measures. Soft measures are for now divided between Floating houses and different adaptive measures. The feasibility of floating houses as a flood risk management measure is dependent on different factors, namely the spatial conditions, the technical conditions and the demand. The first is dictated by the location and policies, which may impose certain requirements linked to a location. Technical feasibility is dictated by policies that set certain building codes that the houses need to live up to. Demand is a combination of the attractiveness of floating homes, their cost, and the need for housing. The latter may also be dependent on location. Policies may shape for instance the design of floating houses, affecting attractiveness. This model and these theories were used to prepare for the research and were ultimately used to reflect on these to create a proper answer on the research question.

3 Methodology

3.1 Interviews

The first two sub questions were answered with the conducting of several interviews. We chose not to perform a quantitative analysis, since questionnaires are taken primarily for analysis of the opinion of a population on the subject. What is needed to answer the research questions are the more specific experiences, related to the possibilities and difficulties of floating neighborhoods. With questionnaires, the answers are drawn up beforehand, giving little possibility to elaborate on the answer. Interviews are a good way to get more knowledge on experiences. (Clifford et Al; 2016). The interviews conducted are so-called semi-structured interviews. This type of interview gives both participants the opportunity to explore issues they feel are important to the study. They are useful for collecting experiences, which is exactly what the research aim is. (Clifford et Al; 2016) In this case, this was necessary because of the interviewees expertise in the subject.

The pool of interviewees consists of municipality officials in charge of project management of the selected cases and the architect for the project in Amsterdam IJburg. There is some overlap between functions of certain persons. For instance, the official from the municipality of Nijmegen was responsible for coordinating the changes in the zoning law, the design, and looking into the financial aspect of the project. The two interviewees related to the project in Amsterdam had some shared insights, due to doing similar work in different stages and having worked together on the project in different capacities. The interviewees where chosen due to their roles in the project. Most where in a position where they knew what decisions were made in the project and the difficulties that where found along the way. They mostly had a broad overview of the project, and not an overly focused specialism.

Figure 4: locations of current floating house projects (Author)

The participants for this part of the research were picked based on data that is available on the projects in the Nassauhaven, Lentse Plas, and IJburg (figure 7), and contacted via phone or email. Since most interviewees are situated in the Randstad, it was convenient for them to conduct the interviews in their office. One interview was conducted by phone. This makes for more difficult visualization of answers and no sight on body language. The former may cause misunderstandings in spatial answers, though the latter should have only limited effect on the results, for the answers sought are factual, and have little to do with personal opinions. Additionally, the data needed to assist answers was handy in the office interviews. For example, area maps and plans, as well as a book on the project in IJburg, Amsterdam. The interviews were conducted in Dutch, as to communicate as clearly as possible.

The interviewees are listed in figure 8.

Number	Function	Organisation	Name
1	Architect of Urban plan	Villanova Architecten	Andries Laane
2	Urban developer	Municipality of Amsterdam	Ilse De Jong
3	Project manager	Municipality of Nijmegen	Piet Otten
4	Project manager	Municipality of Rotterdam	Merel Beerthuizen

Figure 5: List of interviewees and their functions

The third sub-question was answered with a short survey among inhabitants of floating homes, randomly sampled from persons at home at a certain time. This made for a survey among 3 inhabitants. The only case in this study that is realized at this time is Waterbuurt in Amsterdam, for the other projects are still in different stages of development.

Respondents that live in Floating houses in Amsterdam were asked various open questions, regarding the initial reason for them moving into a floating house, the benefits they see now they live in a floating house and the negative side of living in a floating house. The reason only inhabitants in Amsterdam where questioned is that this is the only used case that is already a finished project. There are other floating houses in the Netherlands, though they did not fit the criteria for the main research.

3.2 Analysis

When the interviews were conducted and transcribed, they were analyzed using inductive coding. The reason for this is that although the categories answers can be categorized in are known due to the theory, interviews with experts can give unexpected answers in these categories. Because of this, overlapping code groups were created beforehand from the conceptual model, and the codes themselves were created when reading through the transcripts. Linking comments in different interviews together as they supported or contradicted each other. This made for a clear code tree, that creates categories of answers, from which the (sub)questions can be answered.

3.3 Ethics

In the case of expert interviews, all experts were asked if they agree with being named in the research. This was done because privacy is a right that must be held in regard, while being experts gives merit to their answers and the conclusion drawn from them. After the interviews, none of the respondents had objection in being named in the research, along with their function.

Every respondent was given the opportunity after the interview to strike comments that they thoughts were unsuitable. This opportunity was announced before the interview, with the intent to create a more relaxed and open interview.

Two out of three projects are beyond the stage of alteration, so that this research will have little impact on the plans and realization of those cases. One project was still in the phase where civilians could offer protests, so that information and opinions could be sensitive. This phase should however be complete by the time of writing, though the interview will remain confidential, just as the others.

For the inhabitants of floating homes, privacy need not be compromised. They were all promised to remain anonymous, which may have caused them to answer more freely. Their comments should not be able to affect them, for the inhabitants are anonymous and the project was completed several years ago. When their general impression is written in the research, their comment may create an improvement to the neighborhood, though personal retribution of any kind need not be feared.

3.4 Reflection

The research is comprised of two parts. For the first part, the interviews with experts, there are a few point that could have created a better research. Firstly, two out of three cases is not finished, though one is being realized at the moment. This means that it is possible that not all problems have been found, and that assumptions and plans made by the municipalities may prove faulty, though there is no way to be sure of that at the moment. These interviews however do give a good insight of how different municipalities handle the realization of floating houses and the changes in policies. Second, it may have proven worthwhile to interview more experts involved in the project in different capacities, to gain a more rounded overview, however most experts had a broad view of the plans.

As for the interview with residents of floating houses. A larger sample should have been made, possibly involving other locations of floating houses, not involved in the expert interviews. This should make for a sample that is valid to conduct statistics on.

4 Results

In the following chapter, the findings drawn from the interviews will be laid out and discussed. All information here has been given by the expert respondents. Each sub-chapter will end with a brief conclusion drawn from the interviews, paired with theory.

4.1 Cases

The selected cases consist of Waterbuurt West in Amsterdam (Figure 4). This is a project of the municipality of Amsterdam that has the high density of the inner city. The area consists of 55 floating homes, 17 houses on the dike, and three "pole houses". The other side of the Basin, Waterbuurt Oost, consists of lots where buyers could build their own house. The study focusses on the Waterbuurt West, for most questions could be answered here, though remarks about the East side were made and used in the study. The project is the first in the Netherlands that realizes floating houses on a greater scale. (Drijvend Amsterdam, 2012) This is also the site where the surveys were conducted.

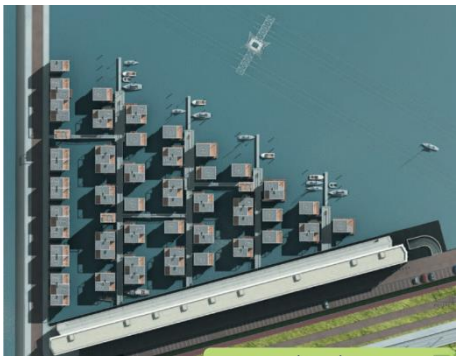

Figure 6: Waterbuurt West, Birds eye view (Drijvend Amsterdam, 2012)

Figure 7: Artist impression Lentse plas (Balance D'Eau, 2018)

Another project used is the expansion in Nijmegen on the Lentse Plas (Figure 5). This lake has a neighborhood its south side, while on north side has a cinema and a city-beach. The water level in the lake varies with the seasons, and the lake has a water storage function. The project will realize around 25 houses. The houses will blend in the surrounding green area from a distance. (ruimtelijkeplannen.Nijmegen.nl). The project is now in the stage where civilians can submit their view.

The last project is the Nassauhaven in Rotterdam. Rotterdam prides itself as innovative Delta-city. The Nassauhaven is an old harbor near the city center that no longer functions as a harbor. This harbor is situated directly on the river Meuse, which has tidal influences at this location. Therefore, the Nassauhaven has a water level that changes constantly. Parallel to the project, a tidal park is being created. The 18 houses will be built on the opposite side of the harbor. (Gemeente Rotterdam, 2018) The houses are being built at the time of writing.

Figure 8: Artist impression Nassauhaven (Public Domain Architecten, 2018)

4.2 Spatial and technical factors

To ensure effectivity of the floating houses as flood risk management measure as well as a house, certain problems need to be solved. In the coming chapter, various features of floating houses that came to light as factors that need to be considered will be discussed, along with the solutions chosen by the executive party and designers.

4.2.1 Water level

A problem mentioned by interviewees 3 and 4, regarding Nijmegen and Rotterdam, is the fluctuation in the water levels. Those were two different kind of problems, for Rotterdam's water level difference is due to the tide, whereas Nijmegen has different levels because of an interaction between the groundwater and the river Waal. Also the basin in Nijmegen is the catchment for rain in the surrounding neighborhoods, meaning that after heavy rain, the basin will have a higher water level (respondent 3).

> *There should always be about half a meter beneath the house. There is a breakaway link, so that the house can be taken to deeper water.*
>
> ***Piet Otten***
>
> ***Municipality of Nijmegen***

This difference means that the projects have a different frequency of water level fluctuation. Both respondent 3 and 4 mentioned a height difference of around two meters. In the municipality of Rotterdam, the pontoons are connected directly to the shore in pairs, whereas Nijmegen has slightly larger groups connected to floating jetties that create a small square with houses around them.

The water level was not mentioned as a problem in Amsterdam, since the difference is about 80 centimeters. Amsterdam uses static jetties above the water, with the houses moving vertically with the water level along bollards.

These solutions show that it is possible to create houses that hold out with several meters of water level difference, which means that floating houses can be effective in reducing the damage case of flooding, even in different configurations with varying conditions.

4.2.2 Balance

A common technical problem, mentioned in all interviews, is the balancing of the house. This is a problem inherent in floating construction. Interviewees 1, 2, and 3 mentioned that the used solution for this problem is adding weight in strategic points. This requires prior knowledge of the layout of the house. The project in Amsterdam uses concrete bases, and adds concrete in the building process. The houses in Nijmegen have composite bases, this type of house has a hollow wall where concrete blocks can easily be added to counter additions to the interior. The latter version seems more user-friendly, allowing for redecorating by the owner, but also by a possible new owner. The size of the houses is also part of the solution for stability. A lower house with a bigger base area is more stable than a narrow tall house.

An added challenge is the balance during construction of the homes. When new material is added, balance should be kept in mind. The common solution for this is building in a kind of dry-dock, this solution is used by all three projects. When not constructing on-site, as is the case here, the waterways will become the sizing factor for the homes. This was mentioned in interviews 1 and 2, about Waterbuurt west, where the smallest lock was the limit for the area of the base. This was not mentioned as a problem in Rotterdam or Nijmegen. Interviewee number 4 mentioned that the houses are using the dimensions of the location, an old harbor, as determinative for the dimensions.

These factors co-create the conditions for the floating homes. As such the attractiveness or profitability, and as such effectiveness, may suffer due to homes that are too small for example.

4.2.3 Fire safety

Fire safety is a common topic that came back in interviews 1, 2, and 3. Buildings must abide by the Housing Law. In interview 3, about the project in Nijmegen, two issues where mentioned. The first is the demand that all front doors are a maximum of 40 meters from the nearest place that a fire engine can reach. Due to the design of the neighborhood, this demand is easily met. Another problem that was solved in Nijmegen is that if a fire is being extinguished in a floating house, due to the water, the house can sink. As a solution, there is a small pump that cannot necessarily put up with the fire department, but help along. If the amount of water gets too heavy, the connection with the jetty will break, sinking the house, but saving the other structures from damage. In the municipality of Amsterdam, the 40 meter demand could not be met. According to respondent 2, as a solution they added so-called “dry-ducts” that the fire department can connect their hoses to. Also provided is a wagon near the entrance of the jetty for the transport of firefighting equipment.

Because of the size of the neighborhood in Amsterdam, along with the facts that the jetty there is public domain and in the time of designing, the law was not suited for this type of projects, an second escape route had to be created in that project, this has been done by interconnecting the jetties, along with the construction of a fireproof barrier in the dead-end sections of the jetty, so that an escape route is always present in case of emergency. According to the interviewee from the municipality of Nijmegen, the law is now providing better adaptable rules for the design of floating houses.

From this can be concluded that floating neighborhoods bring different safety risks with them that may reduce effectivity as a damage reduction measure. National legislation that is meant to reduce these risks may cause further restrictions on the design of the houses.

4.2.4 Water quality

A factor that has more to do with the surrounding landscape is water quality. This was asked after in all the interviews, and all had considered this factor. According to interviewee 2, when the bottom of the home is too close to the bottom of the basin, this will stop water flow, causing conditions for bacteria and algae to be able to contaminate the water. This was solved by sluicing the water when necessary, creating a flow in the water system. Also solutions where created, though not implemented, like the installation of propellers beneath the jetty to stimulate water flow and the addition of floating reed islands to cleanse the water. Furthermore, the house’s shape is restricted so that there is a certain area of water that is treated by the sunlight, which, according to interviewee 2, causes a better water quality. In Rotterdam, the water quality can be furthered by the tidal park that is under construction near the houses. Due to the tidal effect, the flow of the water should be sufficient. Quality was not mentioned as a challenge in this interview. The project in Nijmegen is using composite pontoons, that are more durable and do not have to be treated against algae, so that no pollutants get in the water by cleaning the pontoon. In Nijmegen, the houses are built next to a recreation area that has a beach. The water quality there has to meet a standard for swimming. This means that the houses must not affect the quality of the water by much. The other projects need to meet the outdoor water standard set by Rijkswaterstaat, which breaks down to maintaining or bettering the current quality. In Amsterdam, an additional problem, due to long ducts on the jetty, was a possibility of legionella due to high temperatures, this has been solved with a vent that creates water flow in the ducts, thus securing the water against legionella.

In short, floating houses can cause changes in water quality of the basin where they are located. The minimum quality level is set by Rijkswaterstaat, an national government agency, though additional quality demands may be set by the local government. The quality demands may put a maximum on the number of floating homes. Quality decline can also be resolved with a set of measures, which may make a project more expensive.

4.2.5 Facilities

In all interviews, there was no mention of an additional need of facilities as compared to a regular neighborhood. Most facilities where already present in adjoining neighborhoods. All neighborhoods are accessible by public transport and roads.

4.2.6 Discussion

Floating homes as an idea have a validity as flood risk management measures by virtue of not getting damaged by flooding. There are however factors that make the concept less viable for different reasons. The size and weight of the homes are restricted by local conditions, which may make them less attractive and/or profitable. Furthermore, different kinds of accidents may cause more harm to floating houses than to land-based houses, for example, in case of fire, the water may cause more damage than the fire by sinking the home, creating damage by preventing it. However, there is no reason fires should be more common in floating homes than in land-based houses, which softens the effect. This is also not true in case of small fires that are quickly extinguished. The effect on water quality and the national and local laws regarding this may cause a project to be less profitable or viable, though the impact differs per case. There is no additional need for facilities, though the normal requirements for neighborhoods need to be met.

4.3 Policy

Policies can set criteria for the design, and through this affect the attractiveness and efficiency as a measure of floating homes. In the next paragraph, different experiences of expert on the area of policy will be covered.

4.3.1 Goals

In the interviews, different goals for the projects where mentioned. Though some goals overlapped, some were unique. The smaller projects, in Rotterdam and Nijmegen, wanted to create high-end housing for persons with an interest in water. Amsterdam tried to go for a more mixed neighborhood, spanning from starter housing to more high-end housing.

The wish for a more differentiated neighborhood was also mentioned in Rotterdam, where the existing housing on land is currently low-end and social rental housing. In Addition to these goals, the municipality of Rotterdam uses the project to experiment with more climate-adaptive construction, in line with their innovative character. The site was chosen because it is no longer a functional harbor, giving protection to the new homes, along with a number of different reasons.

> *There are multiple goals that we achieve with this project: Experimenting with climate-adaptive building, the opportunity to change the composition of the neighborhood, the innovative reputation that Rotterdam has, and in the meantime aspects of durability that are taken into account. Those are the goals that we achieve with this project*
>
> ***M. Beerthuizen***
> ***Municipality of Rotterdam***

In Nijmegen, the main reason for the development is to create a more subtle transition from the new land based neighborhoods to the green and blue area around them. This will be achieved by creating some houses on the lakes that mark the beginning of the blue and green areas. This respondent also remarked that it is positive for the process that design and zoning processes were active at the same time, making an integral approach possible.

The project in IJburg, Amsterdam, was created in order to expand the area of the man-made island of IJburg. The project has also been a testing ground for public and private commissioning, one side being entirely commissioned publicly, and the other side in a public-private commissioning. One of

the main reasons that the neighborhood is afloat, is the lack of a loadbearing layer on the bed of parts of the basing, making it unviable for spraying a new part of the island.

The municipalities of Amsterdam and Rotterdam used the projects to create awareness on floating houses, and as such awareness for flood risks can increase. The projects show that the realization of floating homes can be an answer to different problems, spanning from the expanding the city into a larger water body to creating an transition from the city to a green area.

4.3.2 Costs

An interesting difference is the target demographic chosen by the municipalities. The only one that facilitates low-end housing is Amsterdam. When asked about this, respondent 3 said that a part of the reason is the cost of floating homes being too high. One of the reasons for this is the required size of the house to be stable. Villanova Architecten, the designers for the neighborhood in Amsterdam, created a solution to this, joining three low-end houses together, so that the platform was stable while supporting three smaller houses. This so-called “”drie-onder-een-kap” or “one-third-detached” floating homes create a new possible target demographic for bigger floating neighborhoods. Although, the neighborhood still needed the semidetached and detached floating homes to be viable, for the shaping of the public space – the jetty – and all infrastructure is expensive. According to the municipality of Amsterdam, the cheap housing was still too expensive to create social rental housing. Another reason the neighborhood in Amsterdam can be cheaper is the high building density of the project, making the public space more efficient, as well as higher the benefits per square meter.

In Nijmegen, two banks were prepared to finance the houses, making them more accessible, even though they are still high-end housing.

In short, however the more frequently used housing is high-end floating housing, it is possible to create more affordable housing in larger projects or in clusters. Floating housing has become more affordable because of banks willing to finance the purchase of floating homes as real estate. This in turn may be due to the Housing law including floating houses as immoving property, instead of as houseboats.

4.3.3 Utilities

An technical challenge is the delivery of utilities. Due to the vertical movement of the homes, the use of a fixed piping system for water, gas, electricity, internet, and sewage is not possible. It became clear that all projects had different solutions. This is expectable, because of the different spatial features of the projects. The project in Amsterdam, which is a large project, uses fixed jetties in the public domain. According to interviews 1 and 2, this caused the companies responsible for delivery of the utilities to be legally obliged to put the infrastructure on the jetty, delivering to the front door. The last part is the responsibility of the inhabitants of the house, though they are spared the responsibility of maintenance on the jetty, with the other households. To facilitate the infrastructure, the jetty, was adapted for easier maintenance by putting the infrastructure in a through in the jetty.

In Nijmegen and Rotterdam, utilities are delivered to the landing of the jetty on shore. From there on the households are responsible. In these cases, the number of households per landing is lower than in Amsterdam. Two per jetty in Rotterdam and around six in Nijmegen. Adding to this, Nijmegen will no longer facilitate gas in new houses, and the homes in Rotterdam get their own wastewater disposal system, that is not connected to the shore, according to respondent 4.

From this it can be concluded that costs can be higher when accommodating inhabitants in their utility. By making the entrance public domain, the houses have utilities up to their front door. This can however be expensive. In situations where the jetty is private property, inhabitants can come across certain problems. It is up to the local municipality to choose which approach they wish to follow.

4.3.4 Accessibility

Next to these aspects, there is an additional spatial difficulty that needs to be solved: transport. One feature of floating homes that was pointed out by all interviewees was the fact that parking in a floating neighborhood is impractical, not to say impossible. All three projects make use of parking spaces on shore near the houses, with Amsterdam using de garages of new apartment complexes next to the floating homes to facilitate parking. Nijmegen has a cycling street next to the entrance of the jetties, creating good accessibility with so-called active modes. In Amsterdam and Rotterdam, there is also the possibility to reach your house by boat, though that is not always a viable method of transportation for daily trips.

4.3.5 Discussion

There have been changes in the position of floating homes in legislation through the year. Where they started as being hard to classify as inmoving property, the housing law now lets developers choose the category of the house and which criteria they have to fulfill. Through this change, the houses can also get financed more easily, which affects the availability and attractiveness of the project. Most conditions are set by national government regulations, though local government can set extra conditions the houses must fulfill. Local laws can also influence the design of the houses, as is also discussed in the previous paragraph.

Floating houses can be used as a solution for different problems or as an answer to local policy. They can be used to fill in unused bodies of water, expand an area into a body of water that cannot be impoldered, create a link from a neighborhood with a recreation area or to bring some variation into a neighborhood. This means that there can be value gained for governments apart from flood damage reduction.

4.4 Demand

4.4.1 Local government

A focus for all projects was the connection to the water, citing the living on the water as a quality of the project. The measures taken by the designers vary. In Nijmegen, it is possible to have a small non-motorized boat near your house. In Rotterdam, a new tidal park has been developed, along with the possibility to have a boat next to your house, with access to the river Meuse and the North Sea. In Amsterdam, bridges connecting jetties can be opened, allowing for boats next to the houses. Here, the street lighting is adapted, so the stars are visible, giving a vibe of nature and freedom. Both Nijmegen and Amsterdam designed the neighborhood in such a way, that the area still has an open feel to it, and the houses do not become the only sight in the area. In Amsterdam, every house has a wide view of the water, adding to the openness and feeling of freedom.

> *The beauty is that the light is reflected on the water. There is light coming from below as well as above, making it more intense. You're outside a bit more, more contact with the elements.*
>
> ***I. De Jong***
> ***Municipality of Amsterdam***

In interviews 2 and 3, the probable need for green was mentioned. In Amsterdam, inhabitants have put flower boxes on the jetty. In Nijmegen, a possibility for a small garden on the square jetty is considered.

4.4.2 Residents

The respondents from the floating neighborhood were asked about the main reason for their moving into a floating house. Of the three respondents, two mentioned the available space and the living on the water, one stated simple availability as a reason, along with the size of the house. When asked about the benefits of living in the neighborhood that the respondents found since starting to live in a

floating house, all three named the quality of living near the water and the perceived freedom related to this feature. One of the respondents named the possibility of having their sailboat next to the house. Also the line of sight allowed for by the open water was perceived as a quality, along with the relative quietness of the neighborhood.

The floating house related negative features given by the respondents consist mainly of the temperature difference between summer and winter, stating that the house is very hot in summer and the need to heat the house in winter. One respondent mentioned the price of the homes as being higher compared to other parts of Amsterdam as a negative side.

4.4.3 Discussion

Floating houses' main attraction comes from their proximity to water. This quality is enhanced by free sightlines and the ability for water sports to take place in the proximity. These qualities are not inherent to the design, so they should be kept in mind when designing floating housing. The negative side of difficulties in temperature control is inherent to floating homes, though the can be negated. This however will drive up costs further, which will not help the already higher prices of floating houses. The designers try to emphasize the qualities to make the houses more attractive. It is possible for a floating neighborhood to make surrounding areas and function more attractive.

5 Conclusion and discussion

5.1 Conclusion

The main research question to be answered is "What is the feasibility of the realization of floating homes as adaptive flood risk management strategy?". In this paper, interviews were conducted in an effort to answer this question. Different factors for a successful flood risk management were discussed. In this chapter, the conclusions will be summarized and linked to the theory, in an effort to answer the main question.

Firstly, the efficiency of floating homes as a flood damage reducing measure. Floating homes can in fact reduce the damage of flooding by staying afloat. They do however bring certain additional risks with them, stemming from the need to stay afloat. It is also unknown how floating homes will behave in case of high currents for example. This may affect the efficiency of the measure. None of the cases however dealt with this factor. One of the criteria for successful flood risk mitigation is the use of the appropriate scale for a problem (Fornier et al; 2016). In this case, this differs per type of flood risk. To elaborate: floating homes may be a good solution for flooding by excessive precipitation in an area, though it may not be fully helpful when flooding from a river or the sea is in order. Although it may decrease the overall damage done by the emergency, existing inhabitants will find little change in their fate in case of this type of flooding. This is however different when it concerns a fully floating new neighborhood outside the dikes.

Secondly, it has been shown by the gathered responses that the feature of living on the water is perceived as a quality, both by residents and planners. This is supported by Daams et al. (2016) in the statement that water increases the perceived attractiveness. Residents and planners alike subscribe part of the added attractiveness to simple being on the water and being more alongside nature, which is in line with the findings of Rijcken (2006) and Pasternack (2009). This attraction guarantees a certain public awareness of living with water and flood risks, which is deemed a condition for a successful measure (Fornier et al, 2016; Van Vliet & Aerts, 2014; Voogd, 2006). This contribution will however probable not be substantial. Living on the water does not raise additional demands in the form of facilities, only the normal supermarket, schools, parks, etcetera should be available, just as in land-based planning.

Finally, floating homes are found to be useful as solutions to different problems and as means to achieve certain goals, not all involving flood risk management. This means that this type of building can be a tool for governments, who, as concluded before, have gained more legal possibilities to use it. This change in policies is in line with Fornier et al.'s (2016) flexibility in government arrangement. The realization of the floating homes will also have helped with public awareness, though they are not being marketed as a flood risk measure, except in Rotterdam to some extent, that prides itself as an innovator in water management innovation.

From all this can be concluded that floating homes can be a viable flood risk management measure to some extent, though more research into the behavior of the buildings may be necessary for this purpose. In existing neighborhoods, other methods may be more effective in reducing damage done by flooding. Due to being perceived as attractive houses to live in, floating houses may have a position in urban planning nonetheless in other capacities than purely flood risk management. Spatially, floating neighborhoods can be treated as land-based neighborhoods. The inhabitants have the same wants and needs that need to be facilitated, though there was no mention of anything special needing to be added for comfort of living.

Good follow up research may be the behavior of floating houses in other conditions, to find how conditions affect their viability. Also, the further possibilities of floating houses can be researched, because there may be uses that are not mentioned in this research, making the measure usable in different situations. At last, to get a good view on the attractiveness of the houses, a survey with more participants can be of use for the further development of floating houses as a type of residence.

5.2 Reflection

In the conducting of this research, different thing could be bettered. To begin, more information could have been gathered by extending the pool of respondents in the survey amongst inhabitants of floating homes. With this extension, it can be possible to conduct a proper statistical analysis of the opinions of inhabitants, making for a far better insight on the attractiveness of floating houses. It may also prove interesting to survey amongst different floating neighborhoods. Neighborhoods that where not cases in the expert interviews could also be used for this.

During the interviews themselves, it was hard to question the respondents strictly along the question list, which does not have to be a problem in itself. However, during follow up questions, it proved hard to only use non-steering questions, which may have affected the answering.

Furthermore, it could have been of use to interview more experts, to get different views and experiences on one case. Now, certain details may have not been considered when they where not mentioned in the interview about the case. When more, and more differentiated, experts could have been interviewed, the different views on the cases could have become more clear. This could have made for a better understanding of the process and design of floating homes.

It has also become clear that it was hard for me to write a proper theoretical framework. It was hard to find fitting literature, which in turn made it difficult to provide a proper conceptual model. This made it hard to write this paper in such a way that made it clear to readers that are not involved in the writing of the paper. A more clear storyline should be used in following papers, allowing fore a better understanding of the literature and research by everyone, including myself.

6 References

Alphen, J. Van (2015). The Delta programme and updated flood risk management policies in the Netherlands, *Journal of Flood Risk Management*. 9 (4): 310-319

Butler, D; Ward, S; Sweetapple, C; Astaraie-Imani, M; Diao, K; Farmani, R; & Fu, G. (2017). Reliable, resilient and sustainable water management: the Safe & SuRe approach, *Global Challenges* 1(1): 63-77

Clifford, N; Cope, M; Gillespie, T; and French, S. (2016). Key Methods in Geography. SAGE Publications Ltd, London, UK. ISBN 1-4462-9858-9

Daams, Michiel N.; Sijtsma, Frans J.; and Van der Vlist, Arno J.(2016). The effect of Natural Space on Nearby Property Prices: Accounting fo Percieved Attractiveness, *Land Economics* 92 (3): 389-410

Deltaprogramma2019.Deltacommissaris.nl *Accessed 24/12/2018 - https://waterveiligheidsportaal.nl/#/nss/nss/assessment*

Fournier, M; Larrue, C; Alexander, M; Hegger, D; Bakker, M; Pettersson, M; Crabbe, A; Mees, H; & Chrorynski, A (2016). Flood risk mitigation in Europe: how far away are we from the aspired forms of adaptive governance? *Ecology and Society* 21(4): article number 49

Gemeente Amsterdam (2012). Drijvend Amsterdam: De totstandkoming van de Waterbuurt in IJburg, 2012 Amsterdam

Gemeente Rotterdam (2018). Getijdenpark Nassauhaven: Getijdenpark en havenlofts in de Nassauhaven. Accessed 19 Januari 2019, <https://www.rotterdam.nl/wonen-leven/getijdenpark-nassauhaven/>

Gemeente Nijmegen (2009). Landschapszone – 7 (drijvende woningen Lentse Plas) accessed 17 januari 2019, <http://ruimtelijkeplannen.nijmegen.nl/plannen/NL.IMRO.0268.BP24007-/NL.IMRO.0268.BP24007-ON01/t_NL.IMRO.0268.BP24007-ON01.html#_2_Planbeschrijving>

Hung, HC; Yang, CY; Chien, CY; & Liu, YC (2016). Building resilience: mainstreaming community participation into integrated assessment of resilience to climatic hazards in metropolitan land use management, *Land Use Policy* 50: 48-58

Ministerie van Volkshuisvesting, Ruimtelijke Ordening, en Milieubeheer (2009). Drijvende woningen en de bouwregelgeving: Handreiking voor ontwikkelaars, bouwers en gemeentelijke plantoetsers.

De Moel, Hans; Van Vliet, Mathijs; and Aerts, Jeroen .C. J. H. (2014). Evaluating the effect of flood damage-reducing measures: a case study of the unembanked area of Rotterdam, *Regional Environmental change* 14(3): 895-908

Pasternack, R. (2009). Aquatecture: Waterbased Architecture in the Netherlands. *Architecture*, 590

Priemus, H (2017). How housing, infrastructure and water determined the spatial structure of the Randstad, *European Planning Studies* 26 (3): 546-570

Rijkswaterstaat (2014). Deltaprogramma 2014, Werk aan de Delta

Stijnen, J. W; Kanning, W; Jonkman, S. N; and Kok, M (2012). The Technical and financial sustainability of the Dutch polder approach, *Journal of Flood Risk Management* 7 (1): 3-15

Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann,

E. Jansen, B. Kirtman, R. Knutti, K. Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D. Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan and S.-P. Xie, (2013) Technical Summary. In*: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Van Vliet, M. and J.C.J.H. Aerts (2014). Adaptation to climate change in urban water management – flood management in the Rotterdam Rijnmond Area. In: Grafton, R.Q.; Ward, M.B.; Daniell, K.A.; Nauges, C.; Rinaudo, J.D. and Chan, W.W., 2014, *Understanding and Managing Urban Water in Transition.* Springer

Voogd, H (2006). Combating Flooding By Planning; Some Dutch Experiences, *DisP – The Planning Review* 42 (164)

Yin, R. K. (2013). Validity and generalization in future case study evaluations, *Evaluations* 19(3): 321-332

7 Appendix

7.1 Code Tree

Code	Type	Description
Group: Attractiveness		
Openness	Inductive	Using openness to enhance attractiveness
Spatial quality	Inductive	The quality of the public space
Quality of living	Inductive	The quality of living in a floating home
Group: Cost		
Density	Inductive	The number of Floating homes per area
Building cost	Inductive	The cost of a floating home
Group: Design		
Pre-existing situation	Inductive	The situation before the start of the project
Sustainability	Inductive	
Density	Inductive	
Openness	Inductive	
Problems: spatial	Inductive	Difficulties in planning a floating neighborhood
Solutions: spatial	Inductive	Overcoming those difficulties
Problems: technical	Inductive	Difficulties in building a floating neighborhood
Solutions: technical	Inductive	Overcoming those difficulties
Problems: safety	Inductive	Problems regarding different safety issues and laws
Solutions: safety	Inductive	Overcoming those difficulties
Problems: water quality	Inductive	The effects floating houses can have on water quality
Solutions: water quality	Inductive	Nullifying those effects
Group: Effect on failure consequences		
Possibilities regarding flooding	Deductive	The damage reducing possibilities of floating homes
Water management	Deductive	Water management solutions in the projects
Group: Policy		
Laws	Deductive	The laws that are in place that affect the realization of a floating neighborhood
Pre-existing situation	Inductive	
Municipal goals	Inductive	The targets of the executing organization
Target demographic	Inductive	The target income group of the executing organization
Sustainability	Inductive	
Spatial Quality	Inductive	Laws and targets regarding the public space that have to be kept in regard

7.2

7.3

7.3.1 Question list

The interview will start as follows:

- **Introduce myself and project**
- **ask if recording the interview is a problem**
  Question one:
- *Can you tell me what your role in [specific project] is or was*

After this question, the interviewee can be roughly put in one of two categories; city planner or floating home designer. These two categories may not be entirely met, so nuance in the next steps is of essence. A close look should be taken at the questions and irrelevant ones should be forfeit, relevant ones from other groups should be added. Beneath each question, possible probing questions are stated.

For the city planners, the next questions may be relevant;

I. *What qualities make the current location of the projects suitable in your experience? (Sub 1)*
   a. *What qualities are drawbacks?*
   b. *Which of these qualities should be considered for future projects?*

II. *Do the surrounding areas add value to the project? (Sub 2)*
   a. *Or are the projects adding value to the surroundings?*
   b. *Was this a main goal of the project?*

III. *What are the goals of the project? (Sub 2)*
   a. *What makes this different from traditional planning?*
   b. *Are these goals desirable for similar future projects?*

IV. *What commodities are added to the project? (Sub 1 & 2)*
   a. *What was already available in the surrounding areas?*

V. *Would it be a problem if any function would have to be moved for a similar future project? (Sub 1)*

For the engineers and floating home designers, the following questions can be asked;

I. *What are the benefits of the location of the project? (Sub 1)*
   a. *What attributes were altered or specifically designed for the chosen location?*
   b. *What attributes would you want a future project location to have?*

II. *What do you have to keep in mind when designing the floating homes? (Sub 1)*
   a. *What lessons do you have for future similar designs?*
   b. *In what way is this different from more traditional planning?*

III. *What are the requirements for the water to be suitable for the realization of floating homes? (Sub 1)*

It is expected that these questions will create an opening for follow-up questions, which can't be completely accurately predicted. The interview will be closed with the following question:

- *Can you tell me something that you realized about the project while working on it?*

The idea is that interviewees' eye-openers or things that were not covered by the questions will come to light, so that it can be processed anyway.

The interview will be closed by thanking the interviewee for their time and asking if they want anything they said redacted out, so that it won't get quoted. It should also be asked if they want their name mentioned in the final research paper.