Flood resilience in Amsterdam

Measures against flood risk from rising sea levels and increased rainfall

Bachelor project 'Resilience in water management'

Final version

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Abstract

Cities all around the world are facing new issues as a result of climate change. One of these issues is increasing risk of flooding, as a result of rising sea levels and more intense rainfall. Traditional flood control measures are no longer sufficient and a new approach is necessary. A possible approach is the flood resilience approach. This approach includes traditional measures such as dikes, but also includes newer concepts like adjust land-use and making people more aware of the risks. The general idea behind the flood resilience approach is to reduce the consequences of a possible flood event, instead of solely focusing on preventing flood events.

Amsterdam is one of the cities that has chosen for a flood resilient approach. As a coastal city, Amsterdam faces more risks from climate change regarding water. Traditional measures have been implemented for a long time, but now it's time for a new approach. By using both qualitative and quantitative methods this research provides more insight into which measures and policies have been implemented in Amsterdam to work towards a more resilient approach to dealing with flood risk and why these measures have been chosen.

Policy makers aim to make Amsterdam more water resilient by informing people of the risks of flooding and focus mainly on vital and vulnerable buildings and functions. Informing citizens to become more water resilient is less important for policy makers, because it's a smaller scale it doesn't have as much effect, and therefore it's not worth the funds to focus on citizens. Policy makers think Amsterdam is doing well regarding flood resilience, but there is still room for improvement.

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1 Introduction

1.1 Background

As a result of climate change the atmosphere and oceans have become warmer and sea levels have risen (IPCC, 2013). During the 21st century global mean sea level will keep rising and it's likely to raise even quicker than in recent decades (Nicholls & Cazenave, 2010). It's possible that the sea level will have risen by one meter or more by the year 2100 (Nicholls & Cazenave, 2010). Besides rising sea levels, global average precipitation will also increase (Djordjevic et al., 2011). Floods are among the most common environmental hazards, as human communities have often settled along the water (Melo et al., 2015). Rising sea levels and increasing precipitation force scientists and policy makers to re-evaluate flood control measures. The number of flood events has increased during the last century and traditional flood control measures are no longer sufficient (Restemeyer et al., 2015). The problem of urban flooding is also likely to increase, as the number of people living in cities keeps growing and climate change leads to more extreme rainfall (Hammond et al., 2015). Urban flooding can happen in different ways and include pluvial, fluvial, groundwater and coastal flooding (Hammond et al., 2015).

A resilience concept for cities seems promising to deal with the increasing number of flood events (Restemeyer et al., 2015; Kuhlicke & Steinführer, 2013). The basic idea is that "a resilience approach takes the possibility of flooding into account" (Restemeyer et al., 2015, p.46). So instead of just keeping the water away, cities need to increase their ability to live with the water. During recent decades there has indeed been "a shift away from structural and large-scale flood defence towards integrated flood risk management" (Schelfaut et al., 2011, p.825).

1.2 Research problem

Amsterdam is one of the cities with the ambition to become water-resilient (City of Amsterdam, 2013). Keeping the city safe from flood events is a complex task in Amsterdam, because the city has a dense population and the area is situated within three different dike rings, providing different levels of protection. Especially in the area along the North Sea Canal and the IJ resilience is very important, because this area has the lowest protection level. The flood risk level is expressed as "the probability of flooding of flooding that is deemed acceptable" (City of Amsterdam, 2013, p.15). For the less protected area this chance is 1/1,250 per year, compared to 1/10,000 per year for the other parts of the Amsterdam region (City of Amsterdam, 2013). The less protected area is located along the North Sea Canal and the IJ. Because this area has a lower protection level, and is therefore more likely to experience a flood event, this research will look into measures taken that affect this area. This research will into how effective these measures are and if there is room for improvement. Findings from this research could also be useful for other, similar, cities when coming up with new policies regarding flood safety.

Technical measures such as dikes that improve defence against the water have existed for a long time in Amsterdam (City of Amsterdam, 2013). However during recent years policy makers in Amsterdam have implemented measures that focus on adjusting land-use. These measures improve the adaptability aspect of resilience. This research aims to give more insight into the effect of spatial measures on resilience. Therefore this research will focus mainly on the adaptability aspect, but because the three resilience aspects all contribute to a resilient city, robustness and transformability will also be discussed where necessary. It's important to know which already implemented measures have been effective, so policy makers can use this knowledge for future measures.

1.3 Research questions and hypotheses

This research aims to get more insight into flood measures taken by Amsterdam using the following main question: *'How effective are measures taken by the city of Amsterdam for improving the flood resilience in the urban area along the IJ.'* The expectation is that most of the recently implemented measures taken have been effective, but that there are also things that still need improving. Policy makers should be well informed about the situation and are likely to choose for certain measures after careful consideration. Therefore it's likely that most of the measures taken achieve their goals. However, situations can change throughout the years and therefore it's possible some measures have not been effective. In the future it can be expected that more and more measures turn out to be effective, as policy makers can learn from measures taken in the past. They can continue building on effective measures and not implement failed measures again.

To help answering the main questions this research uses a couple of sub questions. The first one is: *'What are the consequences and risks of rising sea levels and increasing precipitation for the Amsterdam metropolitan area?'.* The biggest risks are probably fluvial and pluvial flooding, as Amsterdam is located next to a big canal and the water system is influenced by other rivers in the Netherlands. Also Amsterdam is located close to the coast and coastal regions are more effected by increasing rainfall. Because Amsterdam is a very dense urban area, the biggest challenge is probably not being able to store excess water, as there is probably just no storage room for a lot of water. The next sub question is: *'Which flood control measures exist to contribute to a more flood resilient city?'.* Based on other research that led to this research, it was already clear that there are technical, spatial and informative measures. This will be further explained in the theoretical framework. The following question is: *'Which measures are being taken by policy makers in Amsterdam?'.* From the documents that led to this research focusing on Amsterdam, it is already clear that Amsterdam wants to adjust land-use and elevate functions, so they are taking spatial measures. They have also taken technical measures for decades and it's likely they also want to use informative measures to address all aspects of flood resilience. Because Amsterdam is a dense urban area with little storage capacity for water it's expected that they want to create more room for the water. This is probably also an answer to the sub question: *'What are intentions behind planned measures for the future?'*. Furthermore, it's expected that intentions for the future are roughly the same as the intentions during recent years, as it can be assumed most implemented measures are working and Amsterdam wants to continue building on implemented measures. If not, something probably did not turn out the way policy makers intended.

1.4 Structure

In chapter 2 this research will discuss existing research papers within the flood resilience theme and the concepts these papers provide. Discussing different views on flood resilience will provide a good understanding of flood resilience as a whole and how different views on the topic can be helpful. After that, the methodology of this research will be explained in chapter 3. This consists of the methods of data collection that are used for this research and why these methods have been chosen. In chapter 4 the results of the data collection will be presented, analysed and discussed. Finally, in chapter 5, the results will be used to work towards answers for the main and sub questions. Also in this chapter recommendations for further research will be given.

2 Theoretical framework

2.1 Flood resilience

First of all, the resilience concept has been adopted by multiple disciplines (White & O'Hare, 2014; Restemeyer et al., 2013). In relation to spatial planning resilience is seen as "a normative concept to build capacity to manage specific risks, including climate change, terrorism, flooding and drought, and economic and regional decline" (White & O'Hare, 2014, p.938). While all the different kinds of resilience are relevant for a city, this research will only focus on flood resilience. How does a city build capacity to become more flood resilient and what is flood resilience? In relation to flood management, resilience can be defined as "the capacity of a system, community or society, potentially exposed to hazards, to adapt by resisting or changing, in order to reach and maintain an acceptable level of functioning and structure" (Djordjevic et al., 2011, p. 864). The defining characteristic of resilient communities according to Schelfaut et al. (2011, p. 826) is "the ability to reduce, prevent and cope with the flood risk". Instead of just keeping water away, ''a resilience approach takes the possibility of flooding into account'' (Restemeyer et al., 2015, p.46). The three important factors of resilience, according to Restemeyer et al. (2015), are robustness, adaptability and transformability. However, resilience is a broad concept and therefore there are multiple interpretations of resilience. Hammond et al. (2015, p.15) uses the definition that "a flood resilient city is one with the ability to 'resist, absorb, accommodate to and recover from the effects of a flood hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions'". Although Hammond et al. (2015) attribute different characteristics to resilience than Restemeyer et al. (2015), the characteristics can be compared. Resisting effects of a flood hazard is comparable to robustness, and absorbing, accommodating and recovering can be compared to adaptability. Because many different interpretations of resilience can be confusing, this research will use the interpretation from Restemeyer et al. (2015) to refer to the different characteristics of resilience. The interpretation from Restemeyer et al. (2015) suits this research well, because it makes it easier to assign measures to one certain characteristic of resilience, whereas measures can often be assigned to multiple characteristics if another approach is used.

2.1.1 Robustness

Robustness means that "a city has to be strong to withstand a flood event, for example by building and maintaining dikes, sluices and storm surge barriers" (Restemeyer et al., 2015, p.47). These are pure technical measures to keep water away and reduce the chance of flooding. While technical measures can be part of a resistance strategy focused solely on keeping water away, technical measures are also part of a resilience strategy, because these measures help withstanding flood events (Restemeyer et al., 2015). While technical measures may seem like an 'old' concept, it can still be a very important factor of a resilient approach.

2.1.2 Adaptability

Adaptability implies that "the hinterland is adjusted to flooding so that a flood event may come without leaving damage" (Restemeyer et al., 2015, p.47). This requires both a change in land-use and in social spheres. McEwen et al. (2017) also consider adaptive capacities to be vital, but also mention that if adaptive capacities are not incorporated into a wider framework they are insufficient. It can be concluded that using spatial measures is a good start towards a flood resilient city, but it has to be connected with the other aspect of resilience, especially with transformability.

2.1.3 Transformability

Transformability can be interpreted as “the capacity of a city to make the often demanded shift from ‘fighting the water’ to ‘living with the water’” (Restemeyer et al., 2015, p.47). Kuhlicke & Steinführer (2013) argue that social capacity building is essential to deal with flood risks. Both organisations in charge of flood risk management and individuals should be aware of the importance of social capacities. Kuhlicke & Steinführer (2013, p.115) define social capacity building as “the process of (re-) discovering, enhancing and developing different types of capacities”. For integrating communities into flood resilience planning it’s important to understand how the community works and how much the community knows about flood resilience (McEwen et al., 2017).

2.2 Implications for policy making

Innovative and adaptable strategies are needed if a city wants to become more flood resilient (Hammond et al., 2015). To improve flood resilience and flood risk management in general, the coordination of governmental institutes at all scales is essential (Schelfaut et al., 2011). Also, communities need to be aware of the possibility of flooding and take measures to reduce consequences. Governmental institutes have to help communities with taking measures or take appropriate measures themselves.

Cities using a resilience approach have to shift from sectoral and structural measures towards integrated measures that require much larger involvement from the public and other actors (Restemeyer et al., 2015; Kuhlicke & Steinführer, 2013).

Cities should use a ‘no-regrets’ approach to mitigation and adaptation initiatives. This approach “promotes the necessary changes in behaviour, technology, and policies as simply sound urban management necessary under any circumstances” (Djordjevic et al., 2011, p.869). This approach will most likely improve a city’s resilience capacity.

It is believed that resilience enhancement is a “cost effective and socially equitable way for reducing the flood damage” (Schelfaut et al., 2011, p.826). Golz et al. (2015) conclude that the cost of flood repair decreases by implementing flood resilience technologies.

2.2.1 Technical measures

Building dikes, sluices and other types of barriers to withstand a flood event are possible technical measures to make a city strong (Restemeyer et al., 2015). However with more flood events and rising sea levels, technical measures will not be sufficient, unless they are incorporated into a broader approach. There are also technical measures to store water, for example larger pipes or additional stormwater holding tanks (Siekmann & Siekmann, 2015).

2.2.2 Spatial measures

According to Djordjevic et al. (2011, p. 867) “the severity and frequency of urban flooding can be reduced by better planning policies, which specifically address flooding issues in an early stage”. Planning policies should incorporate the drainage ‘major system’ into the urban landscape during the planning stage. The drainage ‘major system’ consists of above ground flow pathways, instead of the underground piped system (Djordjevic et al., 2011). This is also argued by Siekmann & Siekmann (2015), who argue that technical infrastructure such as streets and parking space can be used as emergency flood paths and retention areas. Implementing flood resilience technologies usually addresses two different spatial scales, the urban scale and the individual building scale (Golz et al., 2015). Policy makers should combine these two scales and make sure smaller measures contribute to a bigger whole.

2.2.3 Informative measures

Early warning systems should be considered as an essential investment for protecting people, property and livelihoods (Schelfaut et al., 2011). Djordjevic et al. (2011) also note the importance of informing people, they argue that it is necessary to have emergency plans for when rainfall exceeds design criteria. “A real time urban flood information system makes it possible to increase the warning time and to get an earlier start on the implementation of the emergency plans, and subsequently it reduces the urban flood damages” (Djordjevic et al., 2011, p. 868). It’s also important to assess which information is needed by citizens and which information is needed by local authorities. Citizens require simple information to make them aware of flood risk, whereas the local authorities need more comprehensive information that will help them implement a flood response strategy (Djordjevic et al., 2011). Communicating information should not be limited to when a flood event occurs, but should also be used to improve awareness and preparedness. By doing so, flood management tools can increase resilience amongst authorities and communities (Schelfaut et al., 2011). Currently flood management tools exist in most countries, but sometimes they are not understood by citizens. A relatively new way of informing citizens is social media. Social media could have great potential to improve disaster communication (Allaire, 2016). An advantage of online information is that citizens can quickly access relevant information. Overall, it’s most important for informative measures to provide specific information to a certain community at the right time.

2.3 Effectiveness

A definition of effectiveness is: “The degree to which objectives are achieved and the extent to which targeted problems are solved. In contrast to efficiency, effectiveness is determined without reference to costs and, whereas efficiency means ‘doing the thing right’, effectiveness means ‘doing the right thing’.” (BusinessDictionary, 2017). This is a very general definition, but it describes effectiveness in a helpful way. Flood resilience measures can be considered effective if they achieve at least some of their objectives. For example, if a measure aims to both reduce the risk of a flood event and also reduce the consequences of a possible flood, it can be considered effective is both goals are achieved. In this case, if only the flood risk is reduced, but there are still the same consequences when a flood occurs, it can only be considered partly effective. The definition from BusinessDictionary (2017) also describes costs as irrelevant for effectiveness, however it’s possible that policy makers have set a goal to keep the costs under a certain amount.

2.4 Conceptual model

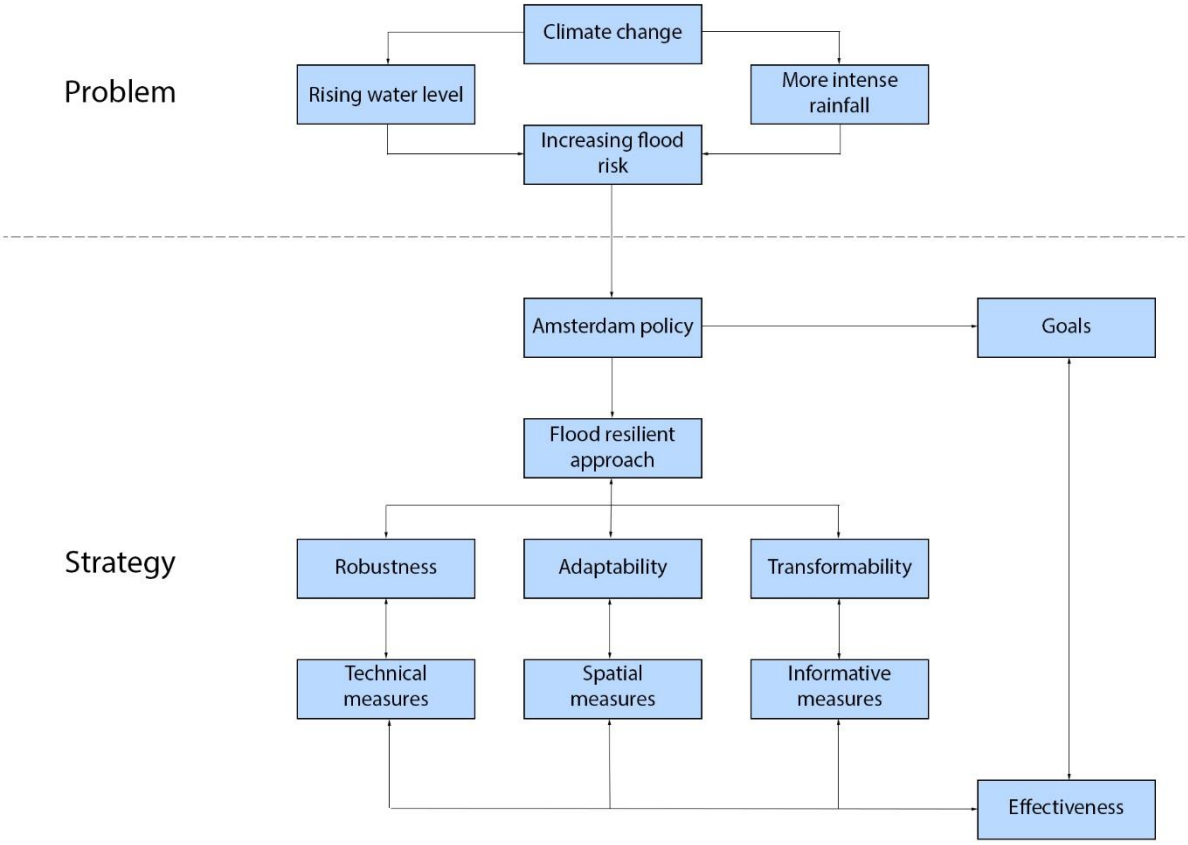

Figure 1: Conceptual model

The conceptual model in figure 1 shows a schematic overview of the problem and the theoretical framework for this research. A resilient approach is required to reduce both flood risk and consequences of flooding. The three key characteristics of resilience, according to Restemeyer et al. (2015) are robustness, adaptability and transformability. The model shows which kinds of measures are usually best suited to improve a characteristic of resilience and what the objective of the measures are. However, implemented measures can also be a combination of smaller measures and therefore belong to more than one characteristic. If the different kinds of measures achieve at least part of the goals of policy makers in Amsterdam the flood resilience approach can be considered effective. If one of the results is not achieved it also helps to determine which part of the resilience approach can be improved. If measures can be considered effective depends on the policy goals, and the effectiveness of measures can also influence future goals, as it will influence how much more change is needed.

3 Methodology

There are two different types of data collection, quantitative methods and qualitative methods (Clifford et al., 2010). “Quantitative methods involve the use of physical (science) concepts and reasoning, mathematical modelling and statistical techniques to understand geographical phenomena” (Clifford et al., 2010, p. 5). While quantitative methods are useful for research, they do not give much insight into subjective meanings. Qualitative methods are better suited for researching subjective meanings, values and emotions. In-depth interviews, participant observation and focus groups are examples of qualitative methods.

For this research both quantitative methods and qualitative methods have been used. To get more insight into the aims of spatial measures taken in Amsterdam to become more water-resilient, 3 interviews have been held with people working for the municipality of Amsterdam, the province of Noord-Holland and Waternet, which is an organisation dealing with water in the Amsterdam region. Because the interviewees will stay anonymous in this research, the sources in the results chapter will be labelled as interviewee 1, 2 and 3. Table 1 shows which organisation belongs to which interviewee.

INTERVIEWEE	ORGANISATION
1	Waternet
2	Municipality of Amsterdam
3	Province of Noord-Holland

Table 1: Interviewees

The aim of the interviews is to provide qualitative data that helps understand the reasoning behind the taken measures, why policy makers chose for these measures and why the policy makers deemed them better than other possibly measures. Understanding the reasoning behind measures helps with understanding the objective of the measures and therefore helps with deciding how effective the measures have been. The interviews are semi-structured, the questions in the interview guide are guidelines (Appendix A). A semi-structured interview gives the opportunity for the interviewed person to explain topics he or she believes to be relevant (Clifford et al., 2010). The interviews have been recorded (with permission of the interviewed person) and transcribed. The recording of one of the interviews failed, but the discussed topics of that interview will still be used. After the interviews were conducted the transcriptions were coded based on keywords. These keywords were chosen after the interviews are conducted, because the interviewed persons have different interpretations of resilience, as it is a broad topic, and therefore used different characteristics to explain the topic. Coding helps with analysing the data by linking topics together and possible providing new understandings of the data (Clifford et al., 2010). Some of the interviewees also provided a couple of documents, which will also be used for this research. These documents add to the interviews and contain extra information about the topics discussed in the interviews.

Furthermore, surveys (Appendix B) have been taken among citizens in residential areas with a lower protection level. Figure 2 shows the part of Amsterdam where the respondents live. Respondents were both approached in person and by a letter in their mailbox (Appendix D). The surveys have been taken anonymously and are relatively simple. This is because most people are not very familiar with the resilience topic, so the questions are not too in-depth. The questions focus on how citizens experience flood risk and how they feel about it. The aim of the survey is to see if measures taken by the city of Amsterdam are considered effective by the citizens. How citizens feel about flood control measures is relevant, because the measures should not only make sure citizens are as safe as possible, but the measures should also make citizens feel safe in their neighbourhood. Also people feeling safe, knowing about measures and knowing what do can be an indicator of a successful policy. Respondents were also asked to provide some general information about themselves, such as age and educational level. Possible differences in experiencing flood risk could be explained by these general variables. If there are differences, perhaps multiple informative approaches are needed to make sure different kinds of citizens are all informed. The intention of this research was to take at least 50 surveys among the citizens in Amsterdam, so that collected data will be representative and statistical tests can be conducted using the statistics program SPSS. Because it was quite difficult to find willing citizens in Amsterdam to fill in a survey and therefore the amount of taken surveys was limited, an online survey tool was used to get more respondents. The respondents for the online version of the survey were reached by delivering a short letter in their mailbox, briefly explaining this research and providing them with a link and a QR-code to the online version of the survey. Combining these two methods of reaching respondents led to 55 useful responses to the survey. For analysing these responses Spearman's correlation test was used in SPSS. This test analyses two different variables to see if there is a correlation between these variables, and also indicates the strength of the correlation. A high correlation value shows that one variable is strongly correlated with the other.

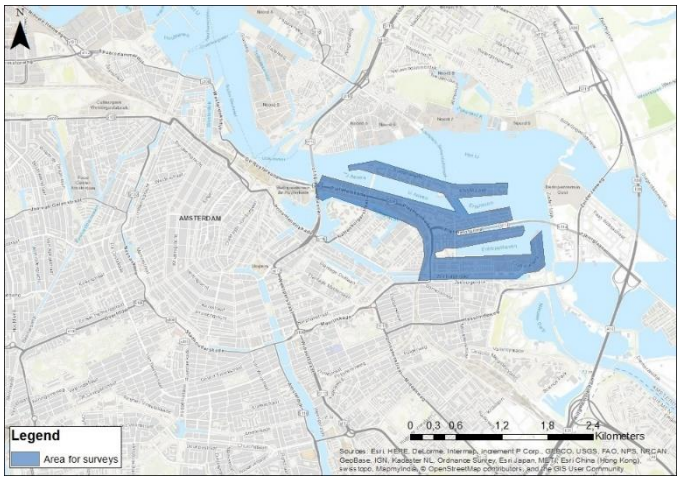

Figure 2: Location for surveys

Ethical considerations in relation to the interviews are making sure there is no bias in the interview questions and that the questions are not too emotional. Also the interviewed persons were asked for permission to record the interview and the data collected from the interviews will be confidential. Interviewed persons will also stay anonymous. Regarding the questionnaires the ethical considerations are more or less the same, except that there is no permission necessary for recording in any way. People have given permission to use the data by filling in the questionnaire, which is done in complete anonymity.

4 Results

4.1 Context

It's important to realize that every region has its own characteristics and the Amsterdam region is no exception. The Amsterdam region is protected from the water by dikes, whereas other cities might be partially situated outside the dike-protected area. These kind of characteristics affect what kind of measures can be taken concerning flood resilience and therefore measures and policies that have proven to be effective somewhere else might not be good options for Amsterdam. Also the Amsterdam region is a very complex region for planning. With a population of 833624 (CBS, 2016) and many important functions everywhere in the area, there is no space where something can be planned without affecting any people or functions. The process for planning is complicated by the amount of parties that are involved in decision making. The municipality of Amsterdam has to cooperate with many parties like the water board Waternet, the province of Noord-Holland and Dutch national governments. Even the within the municipality of Amsterdam there are seven different city districts (Gemeente Amsterdam, 2017; Interviewee 2, Appendix C), which can have their own policies. Also planning within the flood resilience theme is complex, as the Amsterdam region faces issues regarding water safety, robustness, fresh water and climate (Waternet, 2013). To integrate these aspects into policies the different parties have to work together to make decisions.

4.2 Risks and issues

The Amsterdam region can be flooded from multiple sources and if a dike breaks it leads to enormous economic damage and societal disturbance. The consequences of a dike break are not limited to the Amsterdam region, but also affect the Netherlands as a whole and possibly other countries, because economic functions can no longer function properly. The biggest threat for the Amsterdam region is a break of the Lekdike, this would lead to approximately 20 billion euros of damage. This is the highest possible damage in the Netherlands as a result of a dike break. (Waternet, 2013)

Because space is limited, growth in the Amsterdam region leads to more density (Waternet, 2013). A denser area means there are more issues regarding water, heat and drought. Combined with climate change this means there are serious challenges in the area regarding these themes.

Currently, spatial development and water levels are strongly linked together (Waternet, 2013). This is problematic, because fairly small changes in the bosom water levels of the North Sea canal, the Amsterdam Rhine canal, the Amstel and the Vecht cause problems. Problems can be caused in this way by either too much water or not enough water. Therefore the Markermeer is important for Amsterdam, because the regional water network can only hold a limited amount of water. According to the interviewee 2 (Appendix C) this can be increasingly relevant in the future as drought is also becoming a bigger issue and many measures can work both to prevent flooding and to prevent drought.

Next to flood issues from rivers and canals, Amsterdam also faces issues caused by an increase in amount and intensity of rainfall. In coastal areas this increase is bigger than inland (Waternet, 2013). Therefore it's increasingly relevant to have enough storage for water and in the city there need to be measures to decrease drainage speed to prevent flooding. To cope with the risk of flooding from rainfall the municipality has a platform 'Rainproof'. This platform consists of people from the municipality and the water board and aims reduce consequences from intense rainfall.

4.3 Measures

First of all it's important to note that many measures are not taken directly by the municipality or the water board themselves, they talk with parties like companies to implement measures in a resilient way and make policies that contribute to flood resilience. For example, the interviewee 1 (Appendix C) said that Waternet wanted a stricter norm for the Lekdike, which has been honoured in the Delta programme. In the Delta programme there have been pilots concerning the multilayer safety approach, which consists of 3 layers: prevention, sustainable spatial design and crisis management. One of these pilots is 'De Waterbestendige Stad', in which research has been done about the water safety of the Amsterdam region. This pilot has resulted in an overview of possible consequences of a flood in Amsterdam, focussing on the functioning of vital infrastructure and functions, such as hospitals, electricity networks and chemical companies (Interviewee 1, Appendix C). The sustainable spatial design layer can be used to add to more water safety by raising building locations or building water resilient. However, raising building levels is expensive in relation to what is being protected and therefore the multilayer safety approach is connected to other issues to make it worth the investment. Another issue with investing is that the investment usually has to come from companies, and companies often don't know the risks of possible flooding (Interviewee 1, Appendix C). The flood resilience concept as described by Restemeyer et al. (2015) used three different characteristics: robustness, adaptability and transformability. As discussed in the theoretical framework, there are three main types of measures to increase flood resilience and its characteristics: technical measures, spatial measures and informative measures. Flood resilience in Amsterdam is increased by robustness, by implementing stricter norms for certain dikes. Adaptability is also increased by elevating important functions and building more water resilient buildings and infrastructure. However, informative measures to increase the transformability aspect of flood resilience is still lacking. Important companies and other functions are informed of the risks , but according to the interviewee from Waternet, local citizens are barely informed at all. This is mainly because of the situation in Amsterdam, where all areas are situated within dikes. Because the whole area is protected by dikes and the chance of a flood occurring is very low, it does not make a lot of difference if people are told to be prepared for a possible flood, because they don't think it will happen. For this reason Waternet has chosen to focus on informing the vital and vulnerable functions instead of local citizens (Interviewee 1, Appendix C).

To reduce consequences from intense rainfall, the platform Rainproof Amsterdam has taken measures to increase the water storage capacity of the city. Again, many of these measures have to be taken by companies or citizens, but Rainproof Amsterdam has provided subsidies for certain measures. There are subsidies for green roofs and green-blue roofs for citizens, which are so popular not everyone can get the subsidy. There is a limited amount of money per time period that is used to provide people with a subsidy for green roofs, and every time more people apply for a subsidy then the municipality can supply. There is also money for some bigger measures, schools can get a subsidy for renewing their school square if they build it in a more rainproof way. Rainproof Amsterdam also tries to make sure that any newly built areas in Amsterdam immediately make sure to be as rainproof as possible. (Interviewee 2, Appendix C)

4.4 Effectiveness

Whether a taken measure has been effective is hard to say for sure, because of a good overall protection level flooding rarely happens in the Amsterdam region. Therefore it's difficult to measure the effect of implemented measures by numbers, as it can only be compared with the old situation when there is a flood or intense rainfall (Interviewee 2, Appendix C). However, while all parties say

more can and should be done to deal with flooding issues, they feel like they are on the right track. Interviewee 1 (Appendix C) notes that in Amsterdam there is good progress regarding vital and vulnerable functions and it's difficult to find other cities that Amsterdam can learn from. In 2050 Amsterdam wants to be water resilient, and the goal is to have policies to realize that by 2020 (Interviewee 1, Appendix C). Of course, because these are goals for the future there is no way to be certain these goals will be achieved, but there are already policies being implemented. However, policy makers have concluded there is more that could be done (Interviewee 1, Appendix C). While interviewee 1 (Appendix C) says that one of the goals is to increase awareness among companies and that companies are indeed getting more aware of flood risks, interviewee 3 (Appendix C) notes that most companies are not aware of the risks. These interviewees might have a different perception of how are companies are, but it's clear that awareness among companies is currently not as good as desired.

4.5 Surveys

The survey taken in Amsterdam has been filled in by 55 respondents. It's worth noting that all except one respondent have had fairly good education (HBO or WO). Most respondents are at least 35 years old, as shown in table 2. There is no significant relationship between age group and awareness about measures and a safe feeling regarding flooding.

AGE GROUP	AMOUNT OF RESPONDENTS	PERCENTAGE OF TOTAL
UNDER 35 YEARS OLD	5	9,1
35 TO 60 YEARS OLD	29	52,7
60 YEARS AND OLDER	21	38,2

Table 2: Age of survey respondents

When asked if people know what do if a flood should occur, it turned out that many people don't know what to do, as shown in figure 3. This also comes back in the survey when people were asked if they had anything to add, some people noted that they have no clue about what is being done about flood issues.

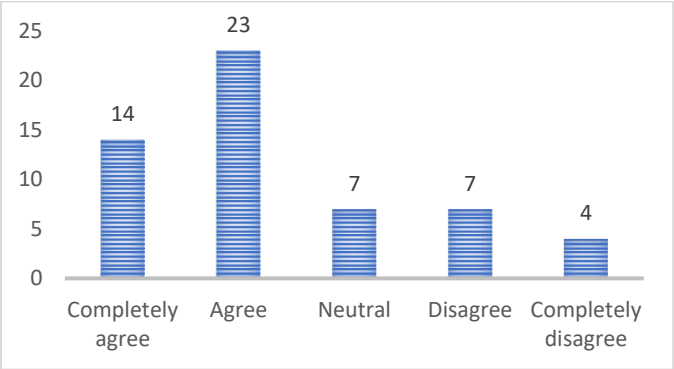

Figure 3: Do people know what to do should a flood occur?

To find out which variables can have influence on knowing what to do when a flood occurs, this research has used Spearman's correlation test. Basically this test shows if there is a significant correlation between two ordinal variables. This research has used Spearman's correlation test on knowing what to versus the other variables from the survey and it turned out that in some cases there was a significant correlation, as shown in table 3. Variables that did not have a significant correlation are not included in table 3. Basically, any significance under 0,05 means there is a

correlation between knowing what to do and the variable and the closer the significance is to zero and the higher the correlation coefficient, the stronger the correlation is.

	SIGNIFICANCE	CORRELATION COEFFICIENT
KNOWING ABOUT IMPLEMENTED MEASURES	0,015	0,327
KNOWING ABOUT FUTURE MEASURES	0,005	0,373
PEOPLE ARE INFORMED ABOUT RISKS OF FLOODING	0,000	0,524
PEOPLE ARE INFORMED ABOUT WHAT TO DO IF A FLOOD OCCURS	0,000	0,551

Table 3: Correlation between knowing what to do and other variables

This data shows that people don't know what to do because they are not familiar with the flood resilience theme. They don't know what is being done to improve flood resilience and especially they are not informed about the theme. This observation confirms the view of Waternet that it's not worth it to focus on informing local citizens. Although people are not really informed and usually don't know what to do in case of a flood event, this doesn't mean they think there is a big problem.

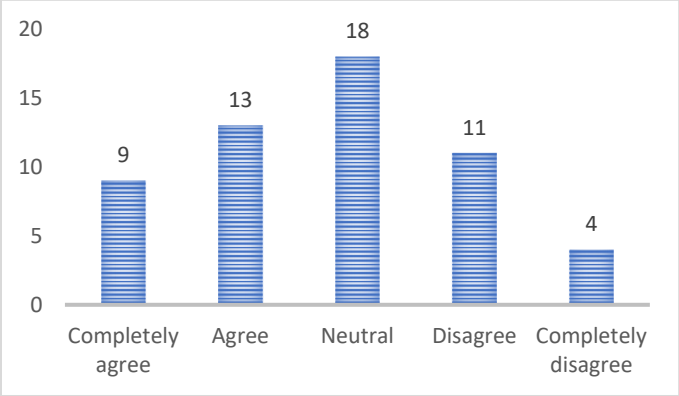

Figure 4: Do people feel safe regarding flood issues?

As figure 4 shows, most people feel safe regarding flood issues. Therefore the decision of not using funds to focus on citizens seems justified. However, figure 5 shows that a fair amount of people see flooding as a threat to their living area, so it is important that something is being done to keep the area safe.

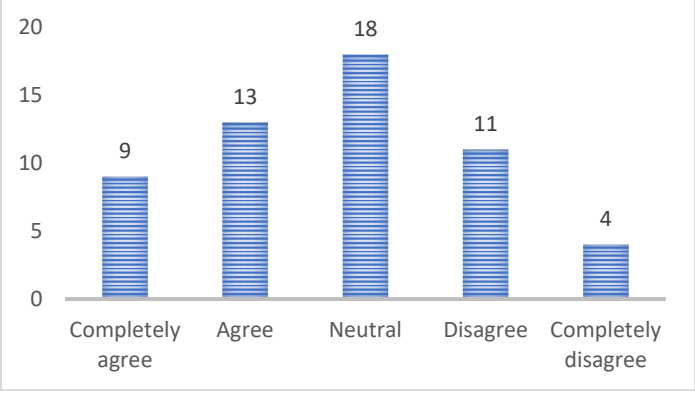

Figure 5: Flood events are a serious threat for the neighbourhood

5 Conclusion

The aim of this research was to find out how effective measures taken by the city of Amsterdam are for improving flood resilience in the urban area along the IJ. To help answer this main question this research looked at the consequences and risks of flooding for Amsterdam, the possible and taken measures to improve flood resilience and the intentions behind both taken and planned measures.

There are big risks regarding flooding in the Amsterdam region, the risk of a flood occurring is low, but if a flood occurs it can have an enormous impact on the society, the economy and infrastructure. This impact would not only affect Amsterdam, but also affect the Netherlands and other countries, because Amsterdam is an important node in many networks.

While there are many possible measures, parties in Amsterdam focus on protecting vital and vulnerable functions when it comes to flood resilience regarding rising water levels. These vital and vulnerable functions are often companies within broad networks and networks itself. Because they usually have to finance measures themselves, parties in Amsterdam focus on informing companies and making them aware of the risks, so that they are more willing to invest in increasing their own flood resilience. Companies can increase their own flood resilience by adjusting land-use, but they have to realize the importance and possibility of doing so. At the moment, many companies are not sufficiently aware of flood risks, which is why policy makers see increasing awareness among companies as one of the main goals regarding flood resilience. On a smaller scale, policies do not really address citizens when it comes to informing about flooding from rivers and canals. Because technical measures have been implemented for decades and provide a very good safety level, most citizens feel safe about flooding and don't think it's necessary to take extra precautions. When it comes to flood issues caused by more intense rainfall, Amsterdam still focuses on bigger parties, but also includes citizens into working towards a more water resilient city. The most relevant ways of doing this are once again informing, but also providing subsidies to improve the willingness of citizens and companies to improve the resilience of their own area.

Based on progress achieved regarding flood resilience it can be said that measures taken in Amsterdam are at least partly effective. It's difficult to measure it by numbers, but measures are being taken to improve flood resilience and more and more is done to make Amsterdam a resilient city. As Amsterdam has the ambition to become flood resilient in the future, it's good that policies are currently being made to make sure flood resilience is increased during the coming decades. However, considering other research, there are aspects that can be done better. While most aspects of flood resilience are covered by measures in Amsterdam, it would be better if there was a stronger connection with the local citizens. It's important that local citizens also know about the risks of a flood event and that they know what to do. However, finances are limited and therefore Amsterdam has chosen to focus more on vital and vulnerable functions instead of local citizens. While a more complete flood resilience approach would be best, the current policy in Amsterdam fits very well considering the limited budget. Future research could be done about how Amsterdam or cities in general could work towards a more resilient approach while on a tight budget, possibly focusing on separate aspect of flood resilience.

6 Reflection

Overall, this research went quite well, the combination of interviews and surveys provided a good understanding of the goals of policies and the effect they have on the community. However, during this research there were things that could have been done better or in a different way. Because flood resilience is a broad topic with many different interpretations, interviewed people often had different views from each other and also different views then existing literature. Therefore it might have been better to research a more concrete or specialized topic within the flood resilience theme, as it was difficult to link the different views sometimes.

An issue with the interviews was that the semi-structured questions left a lot of room for the interviewee to go their own way, which sometimes led to explanations that did not fit very well to the questions asked. The interviewees still provided useful information, but it was harder to link it to the research questions.

There was also room for improvement regarding the surveys. 55 people responded to the survey, which at first seemed enough. However, because the questions had five options, some variables did not have many cases for each option. This made some of the questions less useful for analysing. Therefore it would be good to have more respondents in a next research, it would probably be good to have at least 100 respondents.

References

Allaire, M.C. (2016). Disaster loss and social media: Can online information increase flood resilience? *Water Resources Research*, 52(9), 7408-7423.

BusinessDictionary (2017). *Effectiveness*. Viewed on 30-3-2017 via http://www.businessdictionary.com/definition/effectiveness.html

CBS (2014). *Bevolking; geslacht, leeftijd, nationaliteit en regio, 1 januari.* Viewed on 20-5-2017 via http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=70634ned&D1=0-2&D2=0&D3=0-2,8,21-22&D4=39,82&D5=a&VW=T

City of Amsterdam (2013). *PLAN Amsterdam.* Viewed on 20-2-2017 via https://www.amsterdam.nl/bestuur-organisatie/organisatie/ruimte-economie/ruimte-duurzaamheid/making-amsterdam/planamsterdam-eng/7-2013-amsterdam/

Clifford, N., French, S. & Valentine, G. (2010). *Key Methods in Geography*. 2nd edition. London: SAGE Publications.

Djordjevic, S., Butler, D., Gourbesville, P., Mark, O. & Pasche, E. (2011). New policies to deal with climate change and other drivers impacting on resilience to flooding in urban areas: the CORFU approach. *Environmental Science and Policy*, 14(7), 864-873.

Gemeente Amsterdam (2017). *Stadsdelen.* Viewed on 20-5-2017 via https://www.amsterdam.nl/bestuur-organisatie/organisatie/stadsdelen/

Golz, S., Schinke, R. & Naumann, T. (2015). Assessing the effects of flood resilience technologies on building scale. *Urban Water Journal*, 12(1), 30-43.

Hammond, M.J., Chen, A.S., Djordjevic, S., Butler, D. & Mark, O. (2015). Urban flood impact assessment: A state-of-the-art review. *Urban Water Journal*, 12(1), 14-29.

IPCC (2013). *Climate change 2013: The Physical Science Basis (Summary for Policymakers)*. Cambridge, United Kingdom: Cambridge University Press.

Kuhlicke, C. & Steinführer, A. (2013). Searching for resilience or building social capacities for flood risks? *Planning Theory and Practice*, 14(1), 114-118.

McEwen, L., Garde-Hansen, J., Holmes, A., Jones, O. & Krause, F. (2017). Sustainable flood memories, lay knowledges and the development of community resilience to future flood risk. *Transactions of the Institute of British Geographers*, 42(1), 14-28.

Melo, N., Santos, B.F. & Leandro, J. (2015). A prototype tool for dynamic pluvial-flood emergency planning. *Urban Water Journal*, 12(1), 79-88.

Nicholls, R.J. & Cazenave, A. (2010). Sea-Level Rise and Its Impact on Coastal Zones. *Science*, 328(3985), 1517-1520.

Restemeyer, B., Woltjer, J. & van den Brink, M. (2015). A strategy-based framework for assessing the flood resilience of cities – A Hamburg case study. *Planning Theory & Practice*, 16(1), 45-62.

Schelfaut, K., Pannemans, B., Craats, I. van der, Krywkow, J., Mysiak, J. & Cools, J. (2011). Bringing flood resilience into practice: the FREEMAN project. *Environmental Science & Policy*, 14(7), 823-833.

Siekmann, T. & Siekmann, M. Resilient urban drainage – Options of an optimized area-management. *Urban Water Journal*, 12(1), 44-51.

Waternet (2013). *Deltastrategie Regio Amsterdam: Een regionale uitwerking van het Deltaprogramma.*

White, I. & O'Hare, P. (2014). From rhetoric to reality: which resilience, why resilience, and whose resilience in spatial planning? *Environment and Planning C: Government and Policy*, 32(5), 934-950.