Highlands and lowlands

The influence of elevation differences on the flood risk perception of citizens

Bachelor's thesis

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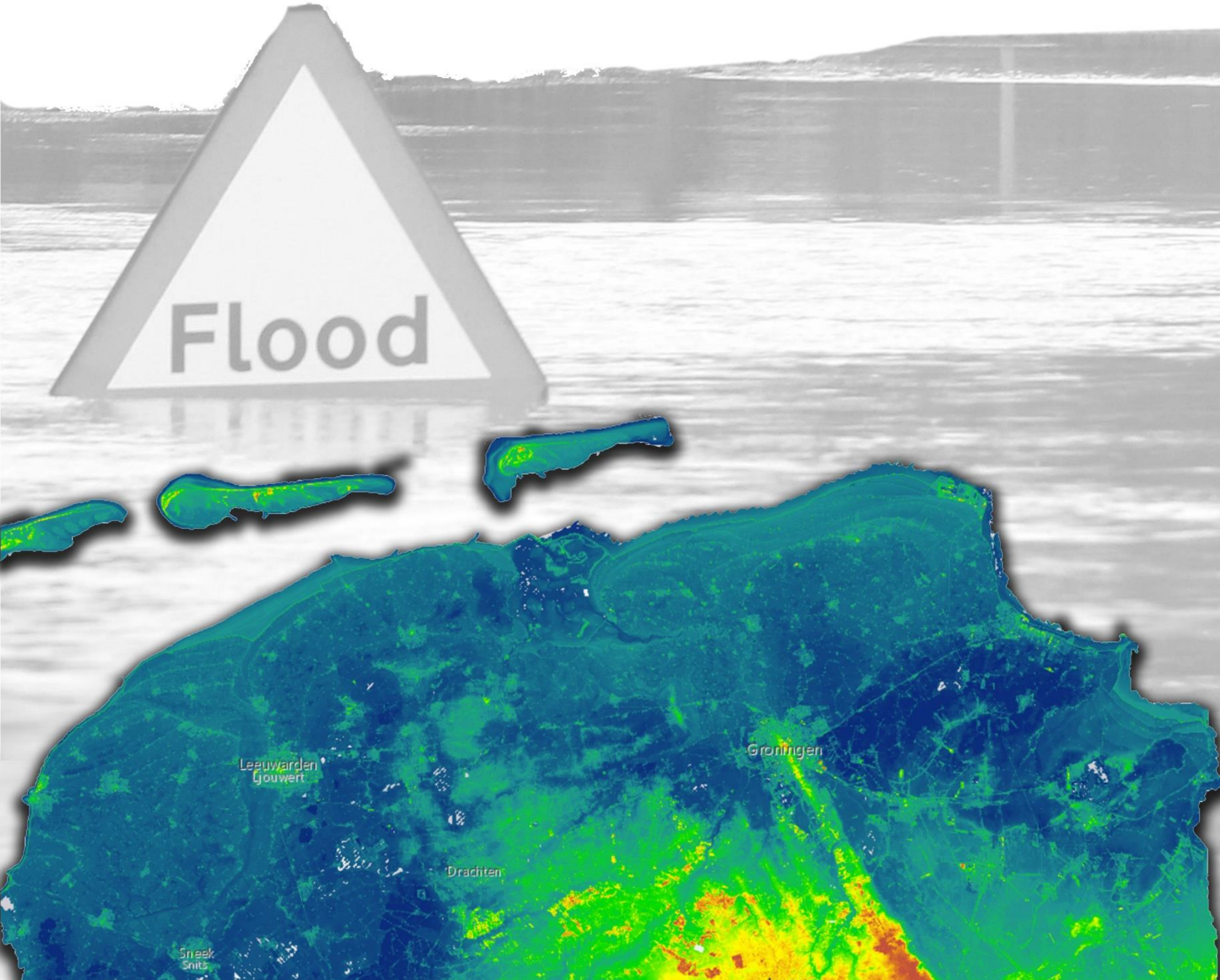

Abstract

The world is facing climate change and its consequences. Especially for a country like the Netherlands, of which the biggest part is located below sea level, the rising sea level, increasing rainfall intensities and higher river discharges will create problems in the future if nothing is done to prevent the consequences. The first step is to raise awareness among citizens. This awareness is influenced by the flood risk perception. This study aims to investigate what this flood risk perception is exactly and to what extent it is influenced by elevation differences. Consequently, the question of this research is what influence elevation differences have on the flood risk perception of citizens around the Eemskanaal in Groningen. By using previous research and theories, risk perception is defined as a concept consisting of four different variables: perceived probability, perceived severity, perceived causes and geographical factors. The latter consists of two sub-variables: perceived distance and perceived elevation. These variables were tested by using a survey for one elevated area and one lower area, both located around the Eemskanaal in the province of Groningen. After comparing these two areas using several chi square tests and t-tests for two different samples, it is concluded that there is no significant difference between lower areas and elevated areas when looking at flood risk perception.

Content

Abbreviations: AHN: *Algemeen Hoogtebestand Nederland*; CBS: *Centraal Bureau voor de Statistiek*; IPCC: *Intergovernmental Panel on Climate Change*; KNMI: *Koninklijk Nederlands Meteorologisch Instituut*; NAP: *Normaal Amsterdams Peil*; NOS: *Nederlandse Omroep Stichting*; PBL: *Planbureau voor de Leefomgeving*; PMT: *Protection Motivation Theory*; SPSS: *Statistical Package for the Social Sciences*.

1. Introduction

All over the world the consequences of climate change are visible and will be even more visible in the future: The sea level will rise (up to 0.59m), rainfall will increase both in numbers and intensity (up to 14% increase in winter) and therefore the chance of a flooding will increase (IPCC, 2014). The Netherlands, famous for their eternal battle between land and water, should be able to deal with these effects, especially the areas that are located below sea level. In the Netherlands, 26% of the land surface is located below sea level, and 59% of the land surface is a so-called flood-prone area (PBL, 2010). To fight these consequences of climate change, several additional measurements are necessary, as well as changes in the mind-set of people, besides the current traditional physical measurements (Restemeyer et al., 2015). This is the case because a change of people's mind-set is essential to make them able to change their view on and attitude towards growing flood risks (Restemeyer et al., 2015). This topic is of societal relevance since flood risk perception of citizens is key for policy, decision-making and the implementation of flood mitigation systems (Botzen et al., 2009). It is important for understanding the public responses to possible hazards (Samuels and Gouldby, 2009). Actually, the perception of flood risk by citizens is an important determinant of the options of minimising flood impacts (Filatova et al., 2011 and Shen, 2010), so it can be about the difference between life and death. Scientifically speaking, there is a lot of research about how to shift from the current traditional flood risk approach (mainly physical measurements) to the adaptability and transformability paradigm, but not about specifically flood risk perception of citizens in flood risk management, which is of great importance (O'Neill et al., 2016).

When aiming for a strong response to growing flood risks, it is not enough to only use the above mentioned traditional flood control measures, but also a more comprehensive risk management approach, which take the reduction of consequences of flood hazards into account. The shift towards this comprehensive risk management approach involves a change in attitude towards flood risks and fighting climate change for both policy makers and citizens (Restemeyer et al., 2015). This is what the concepts of transformability and adaptability are about. Adaptability is defined by Restemeyer et al. (2015) as the adjustment of both the physical and the social environment. Walker et al. (2004) makes a distinction between resilience and adaptability, and transformability: Whereas resilience and adaptability address the dynamics of a particular system (or a closely related set of systems), transformability is more fundamental and is therefore about thoroughly modifying the nature of a particular system. Thus, applying these definitions on flood risk management, the society and its physical elements are within the particular system and transformability refers to changing the nature of the general view on how to act concerning flood risks.

According to O'Neill et al. (2016), the perception of these flood risks is a strong determining factor on the possibility of adjustment of the social sphere. They define the term risk perception as "the combination of the perceived probability of a hazard occurring with the perceived scale of potential consequences" (O'Neill et al., 2016, p 2159). Thus, according to O'Neill et al. (2016) risk perception in general consists of two parts: the perceived probability and the perceived 'severity'. In the theoretical framework, both the various variables of the whole concept of flood risk perception and the placement of flood risk perception in the broader context will be explained further.

1.1 Structure of this study

This study starts with identifying and analysing consisting theories about flood risk perception in the theoretical framework. Here the term 'risk perception' related to floods specifically is placed in a broader context and defined further. This section ends with the research problem, main question, subquestions and expectations of this study. After that, the methodology section shows how these theories are developed into a research strategy, consisting of the used data collection methods, the used analyses and ethical considerations. Then, the results are presented in the results section. They are discussed, linked and compared to earlier-mentioned theories in the discussion section, and the conclusion section sums up all these different results into one clear conclusion. At the end of this study, a reflection on this research and recommendations for further research can be found.

2. Theoretical Framework

2.1 Flood risk perception in the broader context

Before thoroughly exploring the variables of the concept of flood risk perception, it is first placed in a broader context. There is a strong connection between flood risk perception and resilience. Resilience is divided into three concepts: adaptability, transformability and robustness (Restemeyer et al., 2015). Flood risk perception is strongly connected to the adaptability (Restemeyer et al., 2015), or, as written by O'Neill et al. (2016), the possibility of adjustment of the social sphere. Adaptability is especially about 'reducing the concequences of a flooding' (Restemeyer et al., 2015). As Restemeyer et al. (2015) write about 'adjustment of both the physical and the social environment', it will be called social adaptability from now on, which implies knowledge of citizens about flood risks and having the right 'mind-set' concerning flood risks. The flood risk perception positively influences the social adaptability. The higher citizens' flood risk perception, the bigger the possibility to adapt to this risk. The physical adaptabilty (such as elevating houses) is also of great importance in flood risk management, but this is less related to the flood risk perception of citizens. Transformability, which is about 'stimulating societal change', is also connected to flood risk perception, because transformability implies the capacity of a city or region to change based on new insights, and therefore looking for the most suitable way to address flood risks. The three factors of resilience (adaptability, transformability and robustness) are essential for a comprehensive flood risk management (Restemeyer et al., 2015).

2.2 Defining flood risk perception

The perception of flood risk can be measured using a number of sub-concepts, which are discussed here by using earlier scientific work from various authors. Becker et al. (2014) take information from different models to predict flood-reducing behaviour of citizens, starting with the Protection Motivation Theory (PMT) by Grothmann and Reusswig (2006) and Rogers (1983). This model comes with two factors that people use to evaluate the threat of a flooding: The first two are also mentioned by O'Neill et al. (2016): The perceived probability and the perceived severity. The perceived probability can be measured by asking citizens to estimate how often they think a flood happens around their residence. The perceived severity is often measured by letting people estimate the damage in terms of money (Botzen et al., 2009), but this does automatically include the preparedness of the physical elements, such as dwellings. This is not desirable as the stand alone flood risk perception of citizens need to be measured. The perceived water height during a possible flooding can give a better picture of the perceived severity of citizens. This way of indicating the severity of a flood is also done by the Water Management Centre of the Netherlands in cooperation with the Royal Netherlands Meteorological Institute (2017).

Becker et al. (2014) add that, based on theories from Weinstein et al. (1998) and Grothmann and Reusswig (2006), those two factors (perceived probability and perceived severity) are in relation with earlier experiences with flooding. People that experienced a flood before, may have a higher risk perception that people that did not experience a flood before. Also Knuth et al. (2014), Raška (2013) and Dzialek et al. (2013) support this statement. Thus, the flood risk perception is partially built up from a sequence of different linkages, namely: The coping ability of citizens is influenced by their flood risk perception, which consists of the perceived probability and the perceived severity, and those two variabels are influenced by whether or not people experienced a flood before.

Another factor is that, according to Adelekan and Asiyanbi (2016), identifying the potential causes of flooding can contribute to the general representation of flood risk perception of citizens. The percentage of people that identify a particular cause (e.g. heavy rainfall) can say something about their awareness of flooding. The study from Botzen et al. (2009) about various determinants of flood risk perception indicates that people with little knowledge of the causes of flooding have lower perceptions of flood risk. Adelekan and Asiyanbi (2016) categorise eight different causes of flooding for their research in the coastal megacity of Lagos in Nigeria:

- Heavy rainfall
- Blockage of drainage channels with solid waste
- Overflowing of rivers
- Building in floodplains
- Inadequate drainage channels within the city
- Storm surges
- Damming of rivers
- Act of God *(Adelekan and Asiyanbi, 2016)*

Together with the information from the IPCC report (2014), these can be reduced to:

- Extreme rainfall
- Flooding from sea
- Flooding from river
- Flooding from canal
- Melting water from local snow or ice

Before explaining the reduction from eight to five causes, it has to be made clear that there is a difference between a 'source' (or origin) and a 'problem'. A source can be defined as "the place something comes from or starts at, or the cause of something" (Cambridge Dictionary, 2017). A problem can be defined as "a situation, person, or thing that needs attention and needs to be dealt with or solved" (Cambridge Dictionary, 2017). Applying this to floodings, a source is the point or place where the water causing the flood originates before entering the affected area (such as the sea), and a problem is a situation in a particular area which increases the risk of a flood (such as an insufficient sewage system). In this research, a problem is not considered as a cause of flooding, but merely as a 'risk-increasing factor'. For example, 'Building in floodplains' does not relate to a specific point or place where the water comes from, it only increases the risk of a flood event with an (unspecified) cause; e.g. when building in a floodplain area increases the chance of flooding from a sea, this flood event can be classified as a 'flooding from sea'. Also, a failing drainage can be reduced to a flooding from heavy rainfall, for example. Therefore, when using the word cause, it is defined as the source of the water causing the flood. The eight causes shown in the list above can be reduced to five because they are all identical since they can all be attained to a specific origin before entering the affected area of a flood event. To be clear, 'heavy rainfall' comes from the sky before it causes a flood, and 'melting water' comes from snow or ice that melts before it causes a flood.

The last two factors determining flood risk perception are both of a geographical nature. The first one is the perceived distance by citizens to a hazard. It has proved to be a contributing factor to the flood risk perception (O'Neill et al., 2016). This can be measured by taking the difference between the estimated distance to a hazard by a person and the real distance to a hazard from his or her current residence. The second factor that determines flood risk perception is the perceived elevation, i.e. the perceived difference with the sea level on someone's current residence (O'Neill et al., 2016).

2.3 Climate change

As indicated by the IPCC report (2014), the increasing risk of floodings is mainly because of climate change effects. Consequently, the risk is positively related with the size of the effects of climate change, and therefore the perceived probability and severity of a flood event can also be measured by letting citizens give their opinion about these effects from climate change. When this positive relation is applied, someone who does not believe that climate change will have a great impact, automatically has a lower perceived probability and severity, according to the IPCC (2014). To measure and verify this effect, citizens can be asked to estimate the chance of a flooding event for the current situation and for a situation in 40 years from now, for example.

2.4 Other factors

Besides the four different factors as described above, it is also important to consider other factors which do not seem to be directly related with flood risk perception, but could rather influence the perception indirectly. However, are these factors, either directly or indirectly, big determinants of flood risk perception? Zaalberg et al. (2009) investigate prevention, adaptation and threat denial among citizens in the Netherlands and conclude that factors such as age, gender, marital status and level of education do not have a strong correlation with to what extent people are aware of flood risks and their preparedness for a flood event. Moreover, Zaalberg et al. (2009) conclude that perceived elevation is an exception, which has a strong correlation with flood risk perception. In addition, Bubeck et al. (2012) support the conclusion of Zaalberg et al. (2009) that socio-economic factors do not influence the risk perception of citizens and if they do, the correlation is very small. The article of Grothmann and Reusswig (2006) also concludes that the psychological variables are a better predictor of risk-reducing actions of citizens than just sociodemographic facts. When speaking about differences in nationalities and differences between countries concerning flood risk perception, Kellens et al. (2013) help in figuring out whether or not there are differences between countries. In their research, Kellens et al. (2013) discuss many different articles about flood risk management and they conclude that there are significant differences between countries when considering the perception of flood risks. They even mention that in Dutch research (Terpstra et al., 2006; 2009) it is indicated that the Dutch are more fearless compared to other countries. However, the Dutch believe this risk is growing because of global warming. Consequently, the Dutch in general are less aware of flood risks, if we believe previous research.

2.5 Conceptual model

From all the theories discussed above, a conceptual model (figure 1) is developed. This research will focus on the upper part, up to and including 'Flood risk perception', which consists of four main variables. Two of them are influenced by whether or not someone ever experienced a flood before and to what extent someone believes in climate change. These four variables form the basis framework of this study, as all these variables together form a multifaced picture of the whole concept of flood risk perception. The conceptual model also shows where the flood risk perception is positioned in the broader field of flood risk management and resilience.

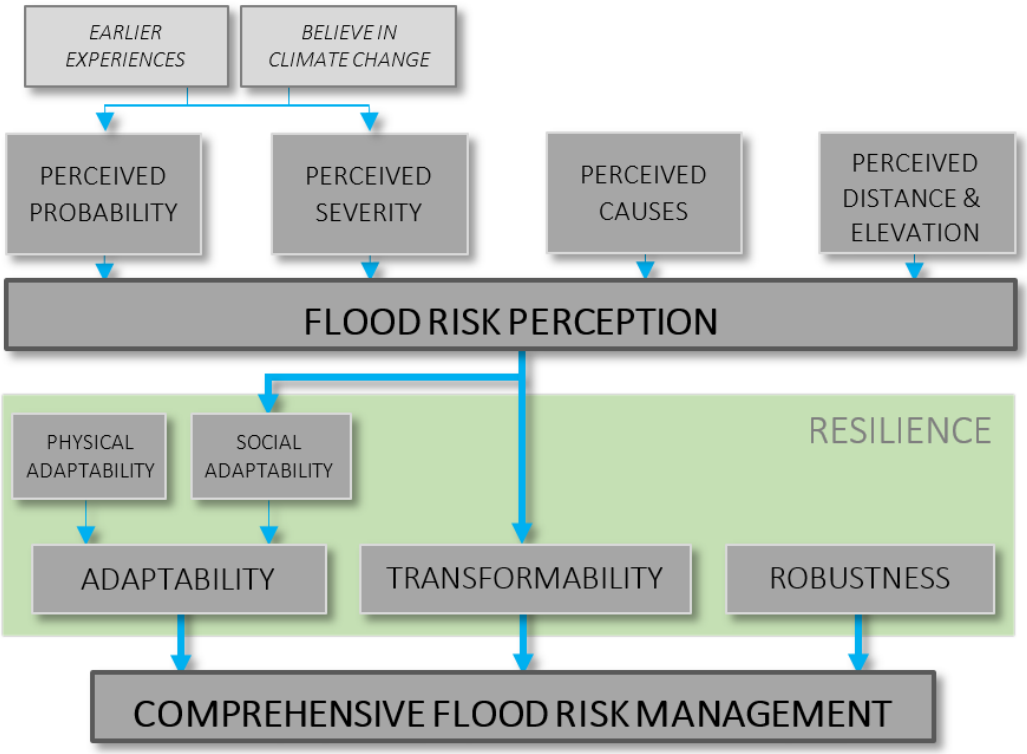

Figure 1: Conceptual model

As written above and as shown in the conceptual model (figure 1), the flood risk perception comprises four different variables: Perceived probability, perceived severity, perceived causes and perceived geographical factors (distance & elevation). More information about how these variables were compared and tested in the chosen study area is written below and in the Methodology section.

2.6 The present study

The theories and concepts on how to live with water and how to shift to a more adaptability and transformability paradigm are already known. This study investigates what the current state of awareness is of people in a particular, relatively, at-risk area in The Netherlands, in relation to the elevation of their residence. The area under investigation is the lower area south to the Eemskanaal in Groningen, with an altitude between 1 and 3 meters below sea level, which is compared to the area north to the Eemskanaal with an altitude between 0,5 below and 1,5 meters above sea level (AHN, 2017). This study thus aims to give an insight in to what extent the people are influenced by their elevation when looking at their flood risk perception. As the flood risk perception is a strong determining factor for the adaptability of the social sphere (O'Neill et al., 2016), it can be seen as a good indicator of the adaptability of this particular region. As the stand-alone influence of elevation differences on flood risk perception of only one specific area is too difficult to measure, two areas with different elevation levels are chosen to make comparisons between these two areas. This results in the following main research question:

What is the influence of elevation differences on the flood risk perception of citizens living close to the Eemskanaal in Groningen?

As the altitude of the low-lying area varies between 1 and 3 meters under sea level (AHN, 2017), the probability of a flood is relatively high in this area, compared to the rest of The Netherlands. In addition, in January 2012 a village close to this area (Woltersum) had to evacuate because of a threat of flooding, due to a lot of rainfall and a high tide (NOS, 2012). Furthermore, information about the chance of flooding is obtained from the website overstroomik.nl (2017), which is based on information from the Water Management Centre of the Netherlands, who make up predictions in cooperation with the Royal Netherlands Meteorological Institute (the KNMI). They give a > 10 % chance of a flood that can happen in a lifetime for the lower area around the Eemskanaal, where the maximum water level during the flood can be 3,5 meters. Another report, The National Flood Risk Analysis for the Netherlands by Rijkswaterstaat (2014) gives a 1/180 chance per year that a flood can happen.

The four variables described above in both text and figure 1 result in the following four sub questions:

- What flood probability do citizens in the lower area expect, compared to citizens in the elevated area?
- How severe do citizens of the lower area expect a flood would be, compared to citizens in the elevated area?
- Which causes of flooding do citizens in the lower area indicate, compared to citizens in the elevated area?
- What differences in distance and elevation are observed between the perceived and the actual values, when asking citizens in the lower area, compared to citizens in the elevated area?

2.7 Expectations

Botzen et al. (2009) did a research about the relationship between (among others) the geographical location and the flood risk perception. They conclude that there is a relation between the elevation of a particular area and the expectation of a flood (i.e. flood risk). According to more recent research of O'Neill et al. (2016), elevation has been found to be significantly related to the perception of flood risks. Their results show that, with a significance value of 0,03, someone's elevation level is related to someone's perception of flood risk. In addition, in the last decades a devastating flood did not occur in the study area, which can lead to a low perception of flood risk, according to Weinstein et al. (1998) and Grothmann and Reusswig (2006). The zero sea level can possibly function as a psychological barrier, so people living below zero would therefore have a different perception than people living above zero. Therefore, the hypothesis of this research is as follows:

The flood risk perception of citizens in the lower area differs significantly from the flood risk perception of citizens in the elevated area.

3. Methodology

3.1 Data collection instrument

After the literature research, of which the results are described in the theoretical framework, more data is collected in the field. This will be described and explained in this section. This study aims to make comparisons between citizens in low-lying areas and citizens in elevated areas. Just as Restemeyer et al. (2015) and O'Neill et al. (2016) did in their research, citizens were the group of interest. It is chosen to investigate citizens in particular because they directly relate to the research question and the major part of people in the study area is inhabitants. When asking for example councillors or other people with a governmental function, the perception of the citizens themselves is not directly addressed. A councillor would earlier be effective when the focus of a research is on the current policy on creating awareness of flood risk.

For collecting data, a lower area and an elevated area were chosen. A quantitative data collection method was chosen, namely surveying citizens in both areas. This is the most appropriate way to answer the research questions, because to give a good picture of the two different groups, a dataset with high variety and enough cases is needed. The choice for quantitative data over qualitative data is made because quantitative data considered as a tool for understanding geographical phenomena (which is here: the influence of elevation differences on flood risk perception) where the use of physical (science) concepts and reasoning is involved, and where mathematical modelling and statistical techniques are used (Clifford et al., 2010). Furthermore, surveys are a useful tool to obtain information about people's perceptions and attitudes towards geographical issues (McLafferty, 2010). When looking at interviews instead of surveys, these are more time consuming per respondent, and more in depth information is obtained from only a few respondents (Clifford et al., 2010). For this research, a general picture of a bigger group is needed. Therefore, surveying better suits this research as it addresses more people than during interviews. The gathered survey responses are considered as quantitative data. This is the case because most questions require participants to fill in numbers that can be used as a ratio variable in the data analysis. The questions where no numerical answers are required, the answers can be divided into groups where the amounts per group can be analysed as quantitative data. To meet the requirements of a reliable statistical analysis, surveying is an appropriate method to get enough cases, and get the right types of data (ordinal, ratio). This is because surveying is, besides to the researcher's perspective, also less time consuming for the respondents than interviewing. A respondent is usually earlier willing to fill in a survey that takes a few minutes than doing an interview of 30 minutes. Consequently, in the same amount of time, more cases are recruited when doing surveys than when doing interviews, and therefore, the requirements for statistical analyses are met easier (McLafferty, 2010).

Surveying is chosen as research method rather than secondary data because firstly, data about flood risk perception of inhabitants is not available for the study area and secondly, if it would have been available, the data may have been manipulated for other purposes than the purpose of this research, and would therefore have been untrustworthy and useless (White, 2010).

3.2 Recruiting participants

The survey was done both digital and face-to-face survey. The participants were approached by going door to door and they were asked whether or not they want to participate in the survey. This door-to-door method is also done in the research of O'Neill et al. (2016), but their conversations took about 30 minutes. As in this research a shorter survey of 10 questions is being conducted, it takes about 5 minutes per participant. If they did not have time at the moment, they were given a paper with a short explanation of the research, a short url to the survey and a QR code (to make it easy accessible on a smartphone). The url is added to make sure that participants without a smartphone can access the survey on a computer or laptop.

The face-to-face method is primarily chosen because then the researcher can gain more information by letting respondents reveal hidden meanings and clarify questions (McLafferty, 2010). This is done by writing down the often-mentioned comments, thoughts and opinions by respondents, as an addition to their responses to the survey questions. This information was used as additional information to the numerical results and it was used to make clearifying the results easier. The online survey is an addition to the face-to-face survey, because now not only the respondents that wanted and were able to do a survey at the moment were recruited, but also the respondents that wanted to do the survey, but were not able at the moment to do the survey were recruited. Furthermore, several target groups were addressed by using both a face-to-face method and an online method, such as elderly people and young people, for example.

3.3 Study areas

The study area is the area around the Eemskanaal, which is located between the city of Groningen and Delfzijl in the province of Groningen in The Netherlands (see figure 2).

Figure 2: location of the Eemskanaal in the province of Groningen

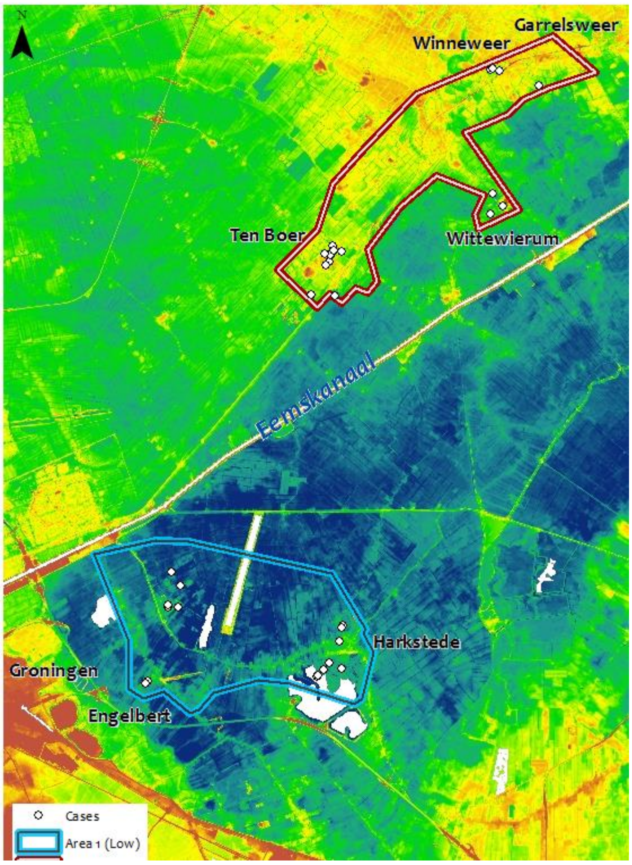

Figure 3: ArcGIS map of areas for data collection including respondents' location (after AHN, 2017)

Table 1: Facts about study areas (after CBS, 2016)

Area	Villages/hamlets	Inhabitants
Area 1 (low):	Harkstede	2 490
	Klein Harkstede	65
	Engelbert	890
	Middelbert	105
Area 2 (high)	Ten Boer	7 352
	Ten Post	680
	Wittewierum	60
	Winneweer	85
	Garrelsweer	495

Table 1 shows the number of inhabitants of the largest villages and hamlets in both areas. The areas shown in figure 3 are chosen based on the elevation map of the Netherlands (AHN, 2017). The elevation of area 1 (lower area) varies between 1 and 3 meters below sea level. The elevation of area 2 (higher area) varies between 0,5 meters below sea level and 1,5 meters above sea level. In comparison: The elevation levels of the research of O'Neill et al. (2016) varied between 0 meters and 37 meters above sea level. As in this study area elevation differences to such a great extent can not be found, the differences have to be smaller. This is not a drawback but rather an advantage. The terms 'high' and 'low' should be considered as relative to each other. 'High' does not mean that it is high relative to the rest of the Netherlands, for example, but only higher than the lower area. Even more important, the high area is still at risk of flooding. That is in fact an essential feature in this research: The high area is located at approximately 1 - 4 meters higher than the low area, but it is still at or just below or above sea level, which means that it can still be at risk of flooding. Furthermore, the level of the Eemskanaal itself varies around the sea level, so also this is sometimes higher than the level of the hinterland (both the high and low area). These differences are small but still significant, but the question is: are they also significantly influencing the flood risk perception of citizens? If so, then it supports the statement that elevation influences the flood risk perception. If not, then elevation only influences the flood risk perception if the elevation differences are at least at a certain value, if we believe the results from O'Neill et al. (2016).

3.4 The variables

Now an overview is given of which specific questions were asked for each of the four variables influencing the flood risk perception, plus the earlier experiences variable. For most of the statistical analyses, which were performed by using the statistical analysis program SPSS, a t-test for two different samples was the most logical option. This is the case because there were enough cases, two groups, independent cases and ratio variables and the aim is to investigate whether or not there are differences between the two groups. For some variables, a chi square test had to be performed, because no ratio variables were present, but ordinal variables.

- Earlier experiences

  For the first two variables (perceived probability and perceived severity) an additional check needed to be done because there may be given different answers for the respondents that experienced a flood before and those who did not. If the significance value crossed the 0,05 level (either it becomes significant or it becomes insignificant), it was considered that the earlier experience of a flood influences the results of the particular question. This is done because of the theory from Becker et al. (2014) and Weinstein et al. (1998), who state that these above-mentioned variables are influenced by whether or not people experienced a flood before. This results in the question if people ever experienced a flood before of which they were aware (so they can remember it). The definition of a 'flood' was given at the beginning of the survey. The definition was as follows: "The inundation of land that is usually dry" (translated from Dutch) (Kernerman Dictionaries, 2017). In the appendix, the full content of the first page of the survey can be found.

1. Perceived probability

   As written by Becker et al. (2014), Grothmann and Reusswig (2006), Rogers and Prentice-Dunn (1997) the perceived probability contributes to the main image of flood risk perception of people. The perceived probability was measured by the two following questions:
   - Respondents were asked if they think a flood near their house is even possible, no matter how small the chance is. This is important, because when asking people immediately to give an estimation of the chance, it is assumed that respondents do think there is a chance of flooding, which is unjustified. Both groups were compared looking at the percentages that answered that there is a chance of flooding using a t-test for two independent samples.
   - Respondents were asked to give an estimation of the chance of flooding by using the commonly used 'once every … years' method, as done by most reports, such as the National Flood Risk Analysis by Rijkswaterstaat (2014). By using a t-test for two independent samples, both groups' given chances were compared.

2. Perceived severity

Becker et al. (2014), Grothmann and Reusswig (2006), Rogers and Prentice-Dunn (1997) name the perceived severity as one of the variables that contributes to the flood risk perception in general. As written in the theory section, estimated damage does not show the real perceived severity, since factors such as the robustness of the physical environment influences the damage costs. Therefore, citizens were asked to give an estimation of the water height. This way of estimating the severity is also found in the predictions of the Water Management Centre of the Netherlands (in cooperation with the Royal Netherlands Meteorological Institute) (2017). In order to make all respondents' answers comparable to each other, they were asked to give an estimation of the maximum water height in case of the worst flood event they can imagine near their house. Then, the given water height levels for both groups (high and low) were compared by the use of a t-test for two independent samples.

➢ Future perception concerning climate change

It is predicted that in the next decades, climate change affects the likelihood of a flooding (IPCC, 2014). The question is whether or not people have a different perception of the severity of flooding's when taking climate change into consideration. Therefore, the last two questions about the flood event chance and the water height during a flood were asked again, but then for a situation in 40 years from now. Then, again the chances and water height levels for both groups were compared. As an additional check, the percentages of people giving a higher chance were compared (the same is done for the water height levels). All the comparisons were checked whether they were significant or not by using a t-test for two independent samples.

3. Perceived causes

Adelekan and Asiyanbi (2016) write that letting people identify potential causes of flooding help to give a better image of the perception of flood risk. As Botzen et al. (2009) wrote, people with little knowledge of possible causes have lower perceptions of flood risk. Therefore, the following two questions were asked in the survey:

- Respondents were asked to name possible causes for a flooding near their house in an open question. They were allowed to give as many answers as possible. Afterwards, the given answers were classified according to the five groups (see theory section) and some additional groups (when an answer is not clear enough to put it in a particular category). Then, the percentage values of the named causes of both groups (low and high area) were compared by using a Pearson chi square test. Afterwards, an additional group called 'Dike breach' had to be made because a certain number of respondents only answered "dike breach" without adding information about the specific location of the dike (sea, canal or river).
- As a follow-up question, the respondents were given five causes: Heavy rainfall, flooding from sea, flooding from canal, flooding from river and melting water from snow or ice, as defined by a combination of the research of Adelekan and Asiyanbi (2016) and the IPCC report (2014). They had to answer which causes they think are more important than others for a possible flooding near their house. This was done by letting them rank these five causes from most important (rank 1) to least important (rank 5). Each cause was then put into new variables: Ranked #1 yes/no. Then for each cause a chi square test was done to see if there is a significant difference between group 1 and 2 for one or more of the five causes. This had to be done this way because when all the causes were kept on their ranks, there were too many expected counts lower than 5, even if an 'Other causes' variable was computed. This has to be avoided because SPSS is unable to perform a test when it contains more than 20 % of the cells where the expected count is lower than 5. To avoid the effect that causes ranked at #2 (which means that it is still considered as an important cause) are impossible to be put on rank #1, another new variable has been computed: Ranked either #1 or #2 yes/no. This was followed by the same process as for the ranked #1 yes/no variable.

4. Perceived distance and elevation

O'Neill et al. (2016) state that the perception of flood risk is also influenced by the perception of people when asking them about distance to a hazard (here: the Eemskanaal) and elevation. Thus, the two things asked for these variables were:

- Let the respondents estimate how far they are living from the Eemskanaal (distance in a straight line). Then, for each respondent the difference between the estimated distance and the real distance was calculated. The information about their location was obtained from their postal code (ESRI Netherlands, 2015). By using ArcMap, the real distance to the Eemskanaal was calculated with the NEAR function. In the end, two comparing methods were used. The first one was just comparing the differences between the estimations and the real values for both groups. But, as the real distance may influence the absolute difference values (someone living 30 kilometres away from the Eemskanaal is more likely to give an estimation one kilometre away from the real distance than someone living only 5 kilometres away from the Eemskanaal), another method is used to avoid this effect. The estimated distance is divided by the real distance, so a 'factor' is derived. The factors from both groups were then compared by the use of a t-test for two independent samples.
- Let the respondents estimate their elevation relative to the sea level (NAP). Then, for each respondent the difference between the estimated elevation and the real elevation was calculated. Then, the differences of both groups were compared by using a t-test for two independent samples.

3.5 How to come to one final conclusion

To come to one clear conclusion, all of the above results were gathered and put into one overview. Then it can be shown if and how many of these variables were significantly different when comparing both groups. The more significantly different variables, the more certain it is that there is a difference in flood risk perception between lower areas and elevated areas.

3.6 Privacy issues

The respondents were made clear in advance which kind of question they could expect, and, of great importance, it was made clear that their responses were treated confidentially and that their responses were not going to be provided to third parties.

To gain as many data as possible and to give the best possible reflection of the real population, it is tried to make the questions not too personal (e.g. not the exact address is asked, but only the postal code). This is done in a way that it is still useful for the research. Asking too personal information from respondents can have a negative influence on the response rate of surveys. Furthermore, this kind of information is not needed according to Zaalberg et al. (2009), Bubeck et al. (2012) and Grothmann and Reusswig (2006).

4. Results

In this section the results are presented. In accordance with the methodology section, the results are divided by the four variables: Perceived probability, perceived severity, perceived causes and geographical factors. The survey had 97 responses: 53 for area 1 (lower area) and 44 for area 2 (higher area).

4.1 Perceived probability

For the perceived probability variable, no significant differences were observed. This can be seen in table 2. Although for the chance estimation question, the respondents in area 1 gave a chance of one flood every 321,49 years on average (against 108,07 years for area 2), this difference is not significant according to the t-test for two independent samples (0,318). The chance given by The National Flood Risk Analysis by Rijkswaterstaat (2014) is one flood every 180 years, which is approximately in the middle between the averages of both groups. Also for the future chance, there is a difference (one flood every 271,30 years for area 1 against one in every 92,17 years for area 2), but this is not enough to be called a significant difference. Also, in both groups approximately the same proportion of the respondents gave a higher chance for the future (58% against 50%).

4.2 Perceived severity

The first significant result can be found under this variable, where respondents in area 1 gave a significantly higher water level than respondents in area 2 (1,6069 meters against 1,0466 meters) according to the t-test for two independent samples (0,019). However, when the same t-test is performed again, but now with the respondents that experienced a flood before left out, this result becomes insignificant (0,061) (see table 2). For the future water height question, both groups' water height values increased, but the difference between the groups relatively decreased, so no significant differences were observed (Area 1: 2,7018 meters; Area 2: 1,9609 meters; significance value: 0,396).

4.3 Perceived causes

The answers from the open question "Can you give possible causes for a flood near your house?" were grouped and then for each cause group a chi square test was performed to find possible differences in the proportions of respondents that named a particular cause. Only for the cause "Heavy rainfall" a significant difference was found: The respondents in area 1 identified significantly more the cause "Heavy rainfall" than the respondents in area 2 (54,7% against 27,3%, significance value 0,006, as shown in table 2). For an overview of all causes, see figure 4.

For the ranking question, only the cause "flooding from canal" was put on rank #1 significantly more than others by respondents in area 2 (Area 1: 18,9%; Area 2: 47,7%, Pearson chi square: 0,002). When looking at both rank #1 and rank #2, also "flooding from canal" identified by respondents of area 2 is observed to be differing significantly from area 1. Here, respondents from area 1 identified the cause "flooding from sea" significantly more than the respondents from area 2 (69,8% against 47,7%; significance value 0,027). In figure 5 an overview is shown for both the #1 and the #1 or #2 analyses.

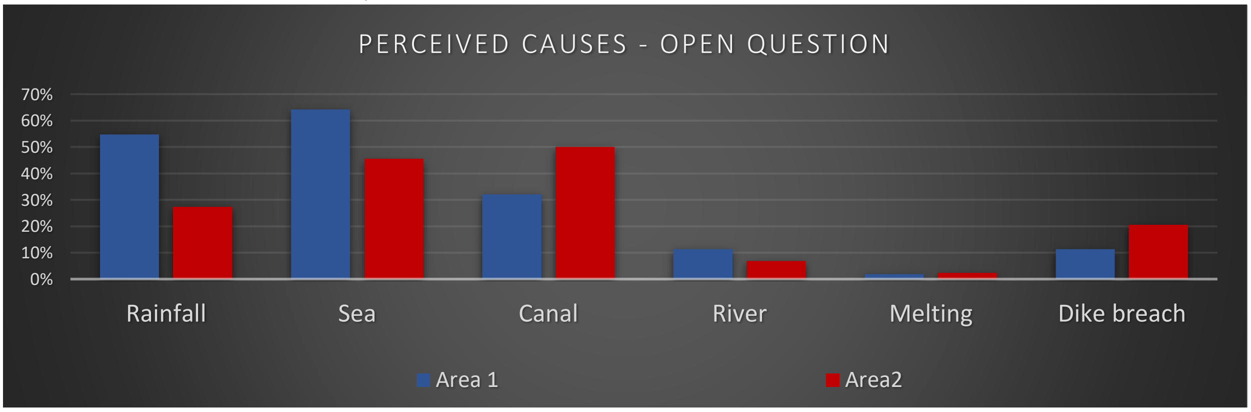

Figure 4: Percentages of respondents' answers of each area for the causes of flooding (own source).

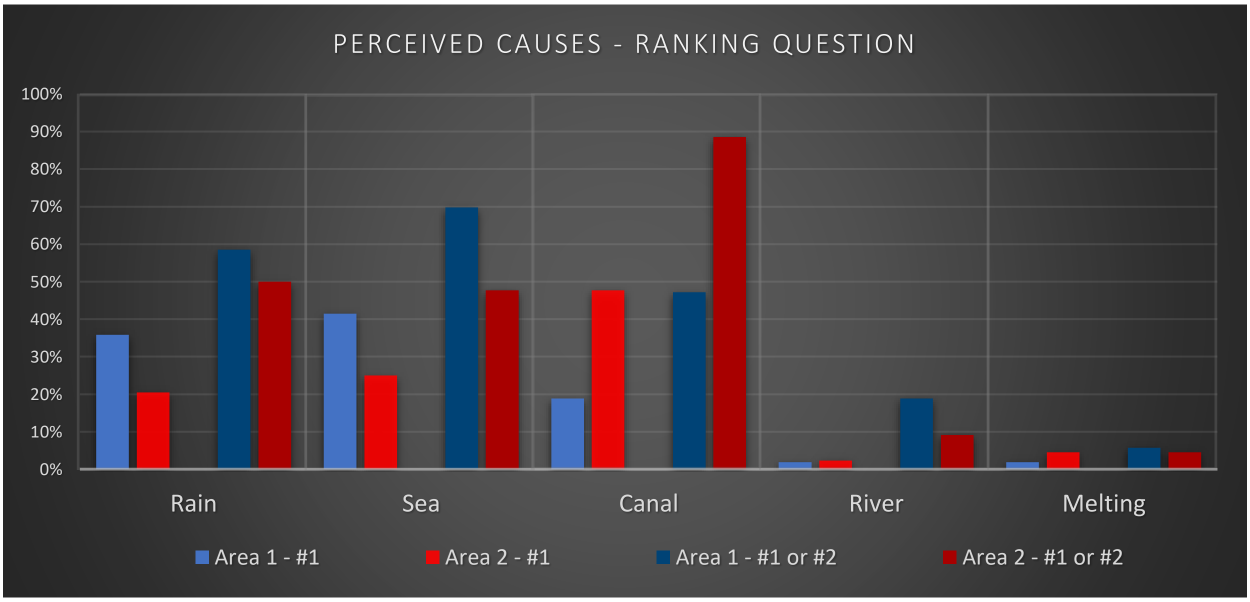

Figure 5: Percentages of respondents that ranked causes of flooding at #1 and #1 or #2, divided by area (own source).

4.4 Geographical factors

For the perceived distance question, no significant differences between the groups were observed. Both the absolute average differences between the estimation and the real distance and the relative differences (estimation divided by real distance) did not show significant results. The perceived distances by respondents compared to their real distances are shown in a scatterplot in figure 6 below. Figure 7 visualizes the averages of both areas of this question.

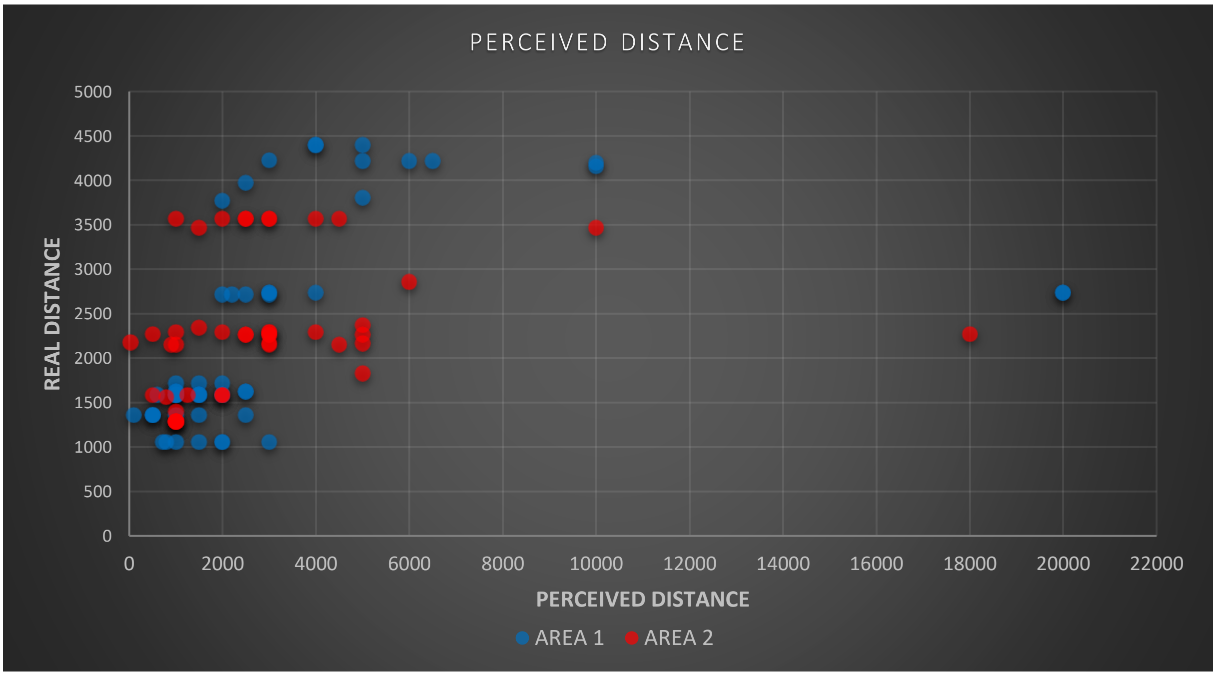

Figure 6: Scatter plot showing respondents' perceived distance compared to their real distance (own source).

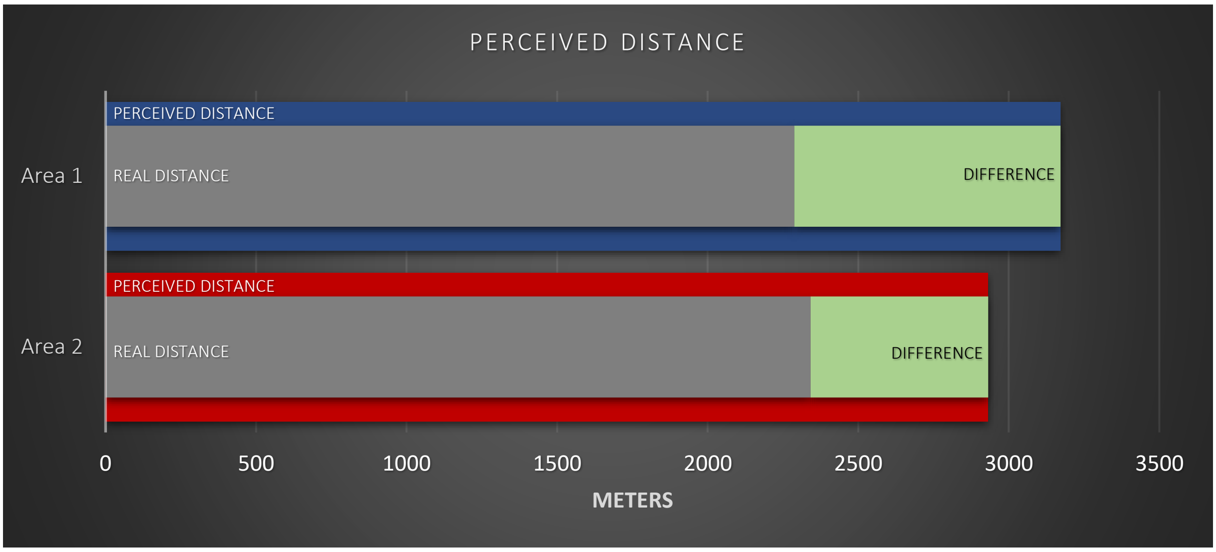

Figure 7: Average real distance compared to the average perceived distance of both areas (own source).

In contrast to this, the perceived elevation question shows a significant difference between the two groups. Namely, in area 2, respondents estimated their elevation level to be significantly more below their real level than respondents in area 1 (-1,2641 meters against -0,1744 meters; significance value 0,019, as shown in table 2). The scatterplot in figure 8 shows the perceived elevation values by the respondents compared to their real elevation values. In figure 9, the averages of both groups are visualized.

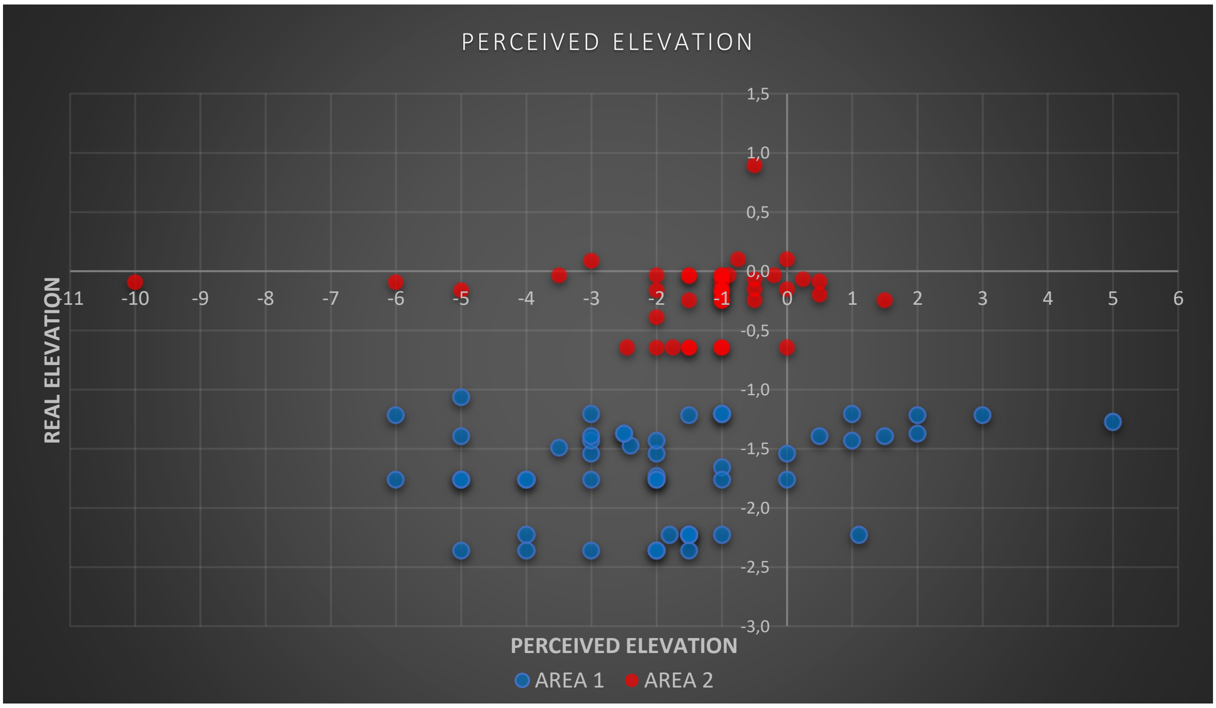

Figure 8: Scatter plot showing respondents' perceived elevation compared to their real elevation (own source).

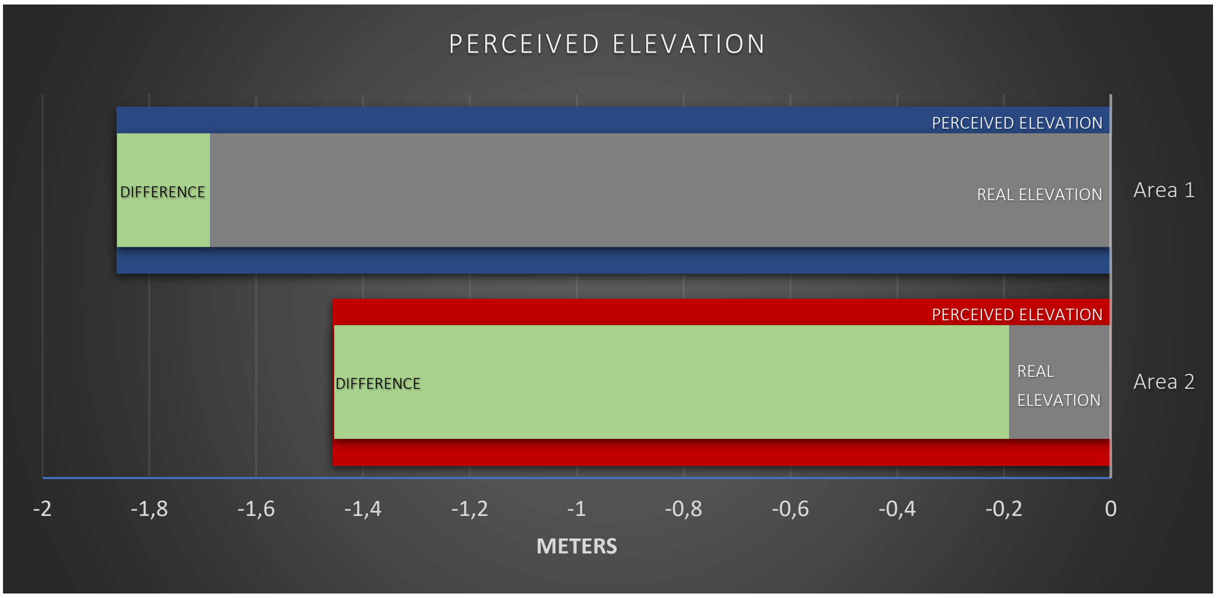

Figure 9: Average real elevation compared to the average perceived elevation of both areas (own source).

In table 2, a broad overview is shown of all results. In table 3, a summary of all variables and their significance values can be found.

Table 2: Overview of all results, including averages and significance values

Variable		Area 1 (low)	Area 2 (high)	Significance	Influence earlier experience
Perceived probability				T-test for two independent samples:	
Do you think there is a chance (no matter how small) that a flood can happen near your house? Respondents that answered 'Yes'		73,6%	86,4%	0,124	No
I expect a flooding near my house every __ years		321,49	108,07	0,318	No
Future: I expect a flooding near my house once every __ years		271,30	92,17	0,416	No
Respondents that gave a greater chance for the future		58,0%	50,0%	0,455	No
Perceived severity				T-test for two independent samples:	
In case of a flood near my house, I expect the water to be at a maximum height of __ meters		1,6069	1,0466	**0,019**	Yes Significance: 0,061
Future: In case of a flood near my house, I expect the water to be at a maximum height of __ meters		2,7018	1,9609	0,369	No
Respondents that gave a greater water height for the future		60,8%	54,5%	0,544	No
Perceived causes				Pearson chi square:	
Open question: Can you give possible causes	Rain	54,7%	27,3%	**0,006**	
	Sea	64,2%	45,5%	0,065	

for a flood near your house? Respondents that Identified:	Canal	32,1%	50,0%	0,073
	River	11,3%	6,8%	0,447
	Melting	1,9%	2,3%	0,894
	Dike breach	11,3%	20,5%	0,215
Ranking question: Can you rank the following 5 causes from most important until least important cause for a flooding near your house? Respondents that ranked at #1:	Rain	35,8%	20,5%	0,096
	Sea	41,5%	25,0%	0,088
	Canal	18,9%	47,7%	**0,002**
	River	1,9%	2,3%	0,894
	Melting	1,9%	4,5%	0,451
Respondents that ranked at #1 or 2:	Rain	58,5%	50,0%	0,403
	Sea	69,8%	47,7%	**0,027**
	Canal	47,2%	88,6%	**0,000**
	River	18,9%	9,1%	0,173
	Melting	5,7%	4,5%	0,805
Geographical factors				
Perceived Distance				T-test for two independent samples:
How far do you think you are away from the Eemskanaal? Average differences between estimation and real distance (in meters):		884,575	589,595	0,663
Factor: Perceived / Real distance:		1,2965	1,2481	0,855
Perceived Elevation				T-test for two independent samples:
How many meters do you think your house is located above or below sea level? Average differences between estimation and real elevation (in meters)		-0,1744	-1,2641	**0,019**

Table 3: Overview of all significance values.

Perceived Probability		Perceived Severity		Perceived Causes				Geographical factors			
Chance Yes/No	0,124			*Cause*	*Open question*	*Rank #1*	*Rank #1 or #2*	Perceived distance		Perceived elevation	
Size chance	0,318	Water height	0,019	Heavy rainfall	0,006	0,096	0,403	Difference Perceived & Real distance	0,663	Difference Perceived & Real elevation	0,019
				Flooding from sea	0,065	0,088	0,027				
Size chance *Future*	0,416	Water height *future*	0,369	Flooding from canal	0,073	0,002	0,000	Factor: Perceived / Real Distance	0,855		
Future chance bigger (percentage)	0,455	Future height bigger (percentage)	0,544	Flooding from river	0,447	0,894	0,173				
				Melting water	0,894	0,451	0,805				
				Dike breach	0,215						

Black = *No significant difference between the two groups*
Blue = *Significant in the direction of the lower area*
Red = *Significant in the direction of the higher area*

4.5 Additional information

Besides these numerical results, some additional information can be gained from conversations during surveying. The most heared reactions from people when they where asked to complete a survey about flood risk perception was "About floodings?", "We don't have floodings here" or something similar. This was the case for both groups, and for both people that participated in the survey and people that did not participate in the survey. Specifically for Harkstede, the biggest village in area 1, people spoke about the fact that the rain water flows away very slowly after heavy precipitation. Also, many respondents (from both areas) were more afraid of heavy earthquakes than floodings. They started talking about earthquakes themselves. And last but not least, many respondents indicated in some way that they did not really feel responsible for protecting their residence. In their opinion, this is a collective task which should be done by the governmental agencies.

5. Discussion

Now the results are discussed. Again, they are splitted up by the four different variables and for each of them explanations are being sought and the results are compared with others.

5.1 Perceived probability

As shown in the results, the perceived probability is lower in area 1 than in area 2, but this difference is not significant. However, when comparing these values to the value given by Rijkswaterstaat (one flood in every 180 years) (2014), then the respondents in area 1 underestimate the chance of a flooding (one flood every 321,49 years) and the respondents in area 2 overestimate the chance of a flooding (one flood every 108,07 years). Although the difference between the two groups is not significant, it is still strinking that one of the groups' average is lower than the value of Rijkswaterstaat, and the other one is higher. When looking at the proportions of the groups who change their mind (i.e. give a higher chance of flooding in the future), in area 1, 58% of the respondents are in accordance with the statement from IPCC (2014) that climate change effects are positively related with the size of flood risks. For area 2, this is 50% of the respondents. There are three possible explanations for the others: (1) These people do not believe in climate change at all, (2) they do not believe that climate change has an effect on the chance of flooding or (3) they think that we, as humans, are able to cope with the effects from climate change (for example by continuing the flood prevention measurements).

5.2 Perceived severity

As presented in the results, two different outcomes are generated when the people that experienced a flood before are either left in or left out the sample. This could be the result of the effect as indicated by Becker et al. (2014), Grothmann and Reusswig (2006) and Weinstein et al. (1998) that if people have ever experienced a flood before, it affects their perceived probability and severity. Now it seems that it influences only their perceived severity.

5.3 Perceived causes

An explanation for the significant difference between the two groups identifying the cause “heavy rainfall” could be that many respondents in the lower area spoke about the fact that there are sometimes problems with rain water flowing away slowly during heavy rain showers in their neighbourhood. This could be a reason for them, either conscious or unconscious, for identifying heavy rainfall as a possible cause. However, this did not apply to all respondents in the lower area, so for this particular cause it can still be said that letting people identify causes for flooding says something about the perception of flood risk, as written by Adelekan and Asiyanbi (2016). A similarity with their research is that “Heavy rainfall” is also a main cause according to the respondents of their survey. However, in this research, this only applies to group 1 (lower area), in group 2 only 27,3% named rainfall as a possible cause.

The cause “flooding from canal” is perceived as significantly more important as a cause for flooding in group 2 than in group 1. This can, probably, be influenced by the fact that the inhabitants of area 2 are living closer to another canal, the Damsterdiep. Although the water in this canal is nowhere near the same level as in the Eemskanaal, it can still be a reason for people to name “flooding from canal” as a possible cause.

5.4 Geographical factors

Probably the most striking result comes from the question where respondents had to estimate their elevation compared to the sea level. Both groups estimated their elevation to be lower than their real elevation (on average), but group 2 did this to a much greater extent than group 1. It seems that most of the respondents in group 2 do not realize that they are actually above or approximately on the same level as the sea level. A clarification could be that most of the inhabitants in the Netherlands know that the northern and western part of the country is considered to be ‘flood-prone’ as it is located below sea level. However, there are certain exceptions within this area, of which some of the respondents probably were not aware. This is a completely different result than the results from O’Neill et al. (2016), where the opposite was observed: People living higher considered themselves to be at a lower risk of flooding. This difference in results is probably partially because of the different elevation levels that are used in the research of O’Neill et al. (2016), namely 0 to 37 meters above sea level, compared to 3 meters below to 1,5 meters above sea level in this research. Also here a clarification could be that people in the higher area of this research do not know that they are actually located around the same, just below or just above the sea level.

6. Conclusion

The results show that most of the tests performed are not significantly different. From the total of 26 tests, 6 turned out to be significant. This means that the other 20 insignificant results contribute to the statement that there is no significant difference in the flood risk perception between people living in lower areas and people in higher areas. In addition, if all test results count equally, the 6 significant results balance each other out: 3 tests point towards the statement that people in lower areas have a better flood risk perception than people in higher areas, whereas the other 3 tests point towards the statement that people in higher areas have a better flood risk perception than people in lower areas. The fact that there is no difference between the lower area and the elevated area might indicate that the adaptability and transformability to flood risks in the lower area is too low.

The hypothesis, which stated "The flood risk perception of citizens in the lower area differs significantly from the flood risk perception of citizens in the elevated area", can therefore be rejected. This is striking as it shows exactly the opposite to what other studies such as Botzen et al. (2009) and O'Neill et al. (2016) concluded. These two studies both found that the elevation of the citizen's location influences his or her expectation of a flood. A drawback for both researches is that their main focus was not to investigate the influence of elevation on flood risk perception, in contrast to this research. Botzen et al. (2009) did a broader research with various determinants of flood risk perception and O'Neill et al. (2016) focused mainly on the influence of distance to a hazard. Another very important difference is that both studies had bigger elevation differences: Botzen et al. (2009) had an average elevation level of -1,48 meters (relative to sea level) with a standard deviation of 6,15 meters, O'Neill et al. (2016) had elevations levels varying between 0 and + 37 meters. These drawbacks can be possible explanations for the difference in conclusions in this research compared to earlier research. Another explanation could be that there are different study areas handled in this research and the above-mentioned studies. Although Botzen et al. (2009) conducted their research also in the Netherlands, their survey had 1000 responses spread out over a much bigger area.

Nonetheless, the results of this research criticizes the statement from Botzen et al. (2009) and O'Neill et al. (2016) that elevation differences influence the flood risk perception. It can be believed that this is the case, but this is more nuanced. A slight difference in elevation does not simply mean that this has an influence on the flood risk perception. This difference has to be of a certain size to have a significant effect. For example, the elevation only causes a significant difference in flood risk perception when the difference in elevation is at least 15 meters.

The results can also say something about the flood risk perception of the lower area itself. Their perception is approximately the same as the perception of the higher area, which means that it could be assumed that citizens of the lower area are not aware enough of flood risks. Keeping this useful information in mind, policy makers are advised to raise this flood risk awareness among citizens in relatively low-lying areas, for example by starting an awareness campaign. Because many respondents did not feel responsible for their own dwelling, but rather relied on governmental agencies, this campaign should definitely include better informing citizens about their own responsibilities. This awareness campaign should thus aim for increasing both the social adaptability and transformability of a society, which is essential for performing a comprehensive flood risk management.

7. Reflection

The goal of this research was to investigate what the influence is of elevation differences on the flood risk perception around the Eemskanaal. This goal is achieved. With the help of different theories of earlier research, multiple variables that determine the flood risk perception were gathered and put into a conceptual model. With the help of this model, survey questions were developed and enough respondents were recruited to perform strong statistical analyses. Therefore, the results can be considered reliable. However, there are some weaknesses observed during and after the research:

- In this research two different groups were of interest. As each group consisted of only one specific area, the results may be different when looking at another location with the same elevation levels. Thus, this research is somewhat 'place-bound'.
- For the open question, too many respondents did not specify the location of a 'dike breach', whereby a new group called 'dike breach' had to be made. It caused many missing values, as these answers could not be put into a group (either 'sea', 'canal' or 'river').
- Although there are differences between the two groups in elevation levels, maybe these differences were not large enough to obtain serious differences in perception of flood risk.

8. Recommendations

To get better and more reliable results, the following recommendations for future research are made:

- As in this research only specific study areas were chosen, the results may only be useful for these specific areas. To get more general applicable results, it is advised to choose various study areas spread out over a greater region when doing further research. Then the results will be less place-bound.
- Not only the location limits the general applicability of the results, but also the time. The research is also held at just one moment. For further research, the research can be conducted over multiple time periods. In this way, the changes over time in opinions and thoughts of respondents about floodings and flood risks can be taken into account.
- Besides choosing multiple study areas, it can be chosen to look for areas where the elevation differences between the high and the low areas are bigger. However, some cases with smaller differences should be kept because of the fact that otherwise only big differences contribute to another flood risk perception.

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