What are Vulnerable Features?

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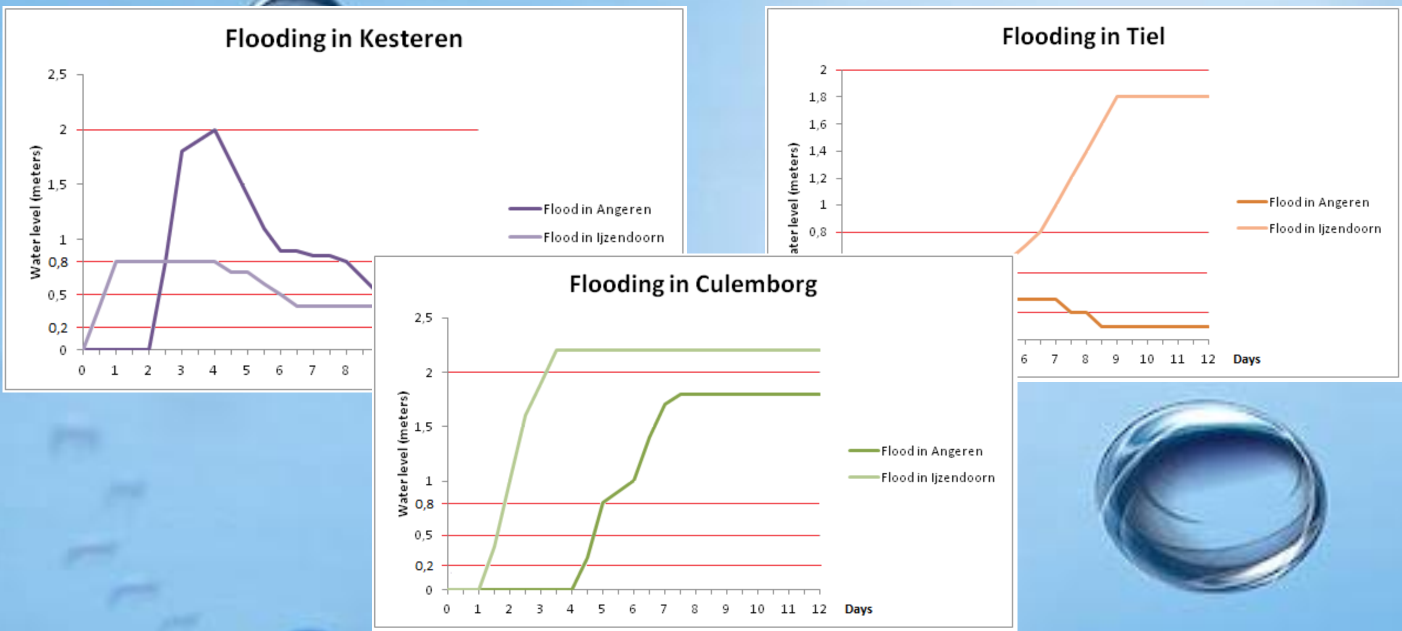

LUP-80436 MSc Thesis Land Use Planning

Veroniek van der Biezen
Student number 880102068040

July 2013

Land Use Planning Group / Province of Gelderland

Wageningen University and Research Centre
Droevendaalsesteeg 4
6708 PB Wageningen

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Master Thesis Land Use Planning submitted in partial fulfilment of the degree of Master of Science in Land Use Planning at Wageningen University, the Netherlands

Veroniek van der Biezen

Registration number: 880102068040

Email: VvanderBiezen@gmail.com

Arnhem, July 2013

Supervisors:

Maarten van der Vlist

Land Use Planning Group

Wageningen University and Research Centre

The Netherlands

Nathalie Hoppenbrouwers-Bos

Programmabureau

Provincie Gelderland

The Netherlands

Mark Zandvoort

Land Use Planning Group

Wageningen University and Research Centre

The Netherlands

Jaap Ruiter

Programmabureau

Provincie Gelderland

The Netherlands

WAGENINGEN UNIVERSITY
WAGENINGEN UR

provincie Gelderland

Abstract

This research focuses on self-reliance of non-self-reliant people. Especially on the environment they live in and the consequences of a possible flood. The research draws on literature research, flood simulations and, interviews within three case-study's, namely a healthcare institution in Kesteren, one in Tiel and one in Culemborg. The flood simulations show that when there is an acute flooding, the consequences are great. Some areas are deeply flooded within a few hours. Also, we can not simply assume that escape routes remain accessible, these also overflow. Vital networks, like electricity, water, ICT and infrastructure are essential in continuing care. In crisis plans of the institutions and plans of the MAAD, the group of non-self-reliant people is considered separately. The dependence of networks is taken into account and particular attention is paid to transport needs. The institutions are obliged to take measures so at least they can continue care for at least 72 hours in case of emergency. The MAAD is a major player with a large network. They can assist in arranging facilities, such as when a disaster happens on a large scale, if the problems are piling up or persist longer than 72 hours. The research shows that more attention should be paid to the vulnerability of vital networks. Also, evacuation possibilities in relation to flood velocity and depth deserve more attention.

Keywords: self-reliance, flood, vulnerable objects, vital networks, healthcare institution

Acknowledgements / Preface

I have always been fascinated by nature. During my time studying, I encountered many different fields of work. Two of those came together during my master. These were spatial planning and water management. These two fields have much in common with each other. Also, they both have to deal with many different people and their wishes. This complexity attracted me. In the Netherlands we complain about the weather and clean water comes from the tap. But the world is changing and many people are working on water related issues to keep the Netherlands safe and to keep potable water available. Since this element is slightly touched upon in my education, I wanted to focus on this in my master thesis. I was lucky to get a place within the Province of Gelderland. Here I was able to experience the professional field and I was near to the developments. Of course the road was long and full of bumps and potholes, especially in defining the research topic and obtaining the interviews, but this thesis proves that I eventually succeeded.

I would like to take this opportunity to thank my supervisors, Maarten van der Vlist, Mark Zandvoort, Nathalie Hoppenbrouwers and Jaap Ruiter, for their guidance and ideas on the topic of this thesis research. Furthermore, you provided me with several very useful contacts and literature. Thanks for all the time and effort that you have invested in reading and commenting on all the draft versions. Thanks for all the interesting and practical experiences you have shared with me. This research is partly based upon information from interviews. Thanks to all the respondents I interviewed for this thesis research. The valuable information from practice that you provided me with gave insight into and up-to-date information about the practical matters related to this research. Furthermore, thanks to everybody else who supported me in writing this thesis; especially Bart whom had to deal with my complaints and my mom with whom I drank a lot of coffee.

Veroniek van der Biezen

Arnhem, August 2013

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Summary

This thesis is inspired by the concept of Flood Site Management (FSM). The main interest is in the third layer, with a focus on the position of non-self-reliant people in healthcare-institutions in FSM. In order to gain insight in this topic, the concepts regarding vulnerability, exposure and self-reliance were used to look at three locations (Kesteren, Tiel and Culemborg) in dike ring 43 as an exemplary case. This study will investigate to what extent the evacuation needs of vulnerable groups in society is being addressed in dike ring 43 in the Province of Gelderland, in the context of the operationalization of the third layer of FSM. The main research question is: ***"What is vulnerability in the case of a flood and to what extent this is already taken into account in the context of evacuations of non-self-reliant people in healthcare institutions?"***

The main reason for this research is to contribute to the scientific debate on the contribution of the third layer. This study also contributes to the decision making process about the operationalization of the third layer of the FSM policy package for flood mitigation and can inform key policy actors on how to accommodate the interests of vulnerable groups in society. By doing this thesis I tried to gain insight in how we are dealing with healthcare institutions in flood prone areas, on a spatial and social level, related to flood safety. To do this, a literature review was carried out to gain insight in the topic and to define non-self-reliance. The Flooding Lizard program was used to determine the exposure of the three healthcare institutions in case of a flood occurring in Angeren or in Ijzendoorn. Interviews were used to establish the vulnerability of the three healthcare institutions.

Self-reliance is defined as: all acts performed by individuals and organizations other than the emergency services in preparation for, during and after a flood disaster, to help themselves and others and to reduce the impact and consequences of flooding. It is assumed that, before the start of the evacuation, citizens have organized themselves in such a way that only people who need medical (or psychological) care are not self-reliant. The institutions are vulnerable objects, but they are prepared for any kind of disaster. They have plans in which their arrangements for a shortage of staff; large supply of patients; closure of (parts of) the location; failure of equipment; logistics stagnation; an outbreak of infectious diseases in an institution; and moving the patients are described. All of these are necessary to continue care. And by taking care of this they can battle any problem. If problems arise, the MAAD can assist them through its contacts and 'umbrella' function in healthcare. All institutions showed that they are capable of taking care of themselves for at least 72 hours.

In order to function properly, all healthcare institutions rely heavily on electricity, water, personnel, telephones, computers, logistics and all networks used by these. The functioning of vital networks is crucial for the functioning of an area, because failure can cause social disruption (victims / economic damage). Preparing for an evacuation takes time. This is certainly the case in a healthcare facility where people are less able to do things themselves and this proves to be the main problem. The institutions are aware of the dangerous situation that can arise if people get stuck in traffic while fleeing the area during a flood. All institutions showed that they need at least twelve hours to get ready for an evacuation. In an acute situation this is not always possible. The biggest problems would arise if problems occurred at night since less staff is present at that particular time. The vulnerability of critical infrastructure should be properly included in the emergency plans. We can make many plans, but the limiting factor is the human being. We are on the right track, but we are not there yet.

Samenvatting

Deze thesis is geïnspireerd door het concept van Meerlaagsveiligheid (MLV). De voornaamste interesse ligt in de derde laag, met een focus op de positie van niet-zelfredzame mensen in instellingen voor de gezondheidszorg binnen MLV. Om inzicht te krijgen in dit onderwerp zijn concepten met betrekking tot kwetsbaarheid, blootstelling en zelfredzaamheid gebruikt om te kijken naar drie locaties (Kesteren, Tiel en Culemborg) in dijkring 43. Deze studie zal onderzoeken in hoeverre de evacuatie behoeften van kwetsbare groepen in de samenleving wordt aangepakt in dijkring 43 in de provincie Gelderland, in het kader van de operationalisering van de derde laag binnen MLV. De centrale onderzoeksvraag is: ***"Wat is kwetsbaarheid in geval van een overstroming en in hoeverre wordt hiermee reeds rekening gehouden in het kader van de evacuatie van niet-zelfredzame mensen in zorginstellingen?"***

De belangrijkste reden voor dit onderzoek is een bijdrage te leveren aan het wetenschappelijk debat over de bijdrage van de derde laag. Tevens draagt deze studie bij aan het besluitvormingsproces omtrent de operationalisering van de derde laag binnen het MLV beleidspakket voor de mitigatie van overstromingen en kunnen belangrijke beleidsmakers geinformeerd worden over hoe de belangen van kwetsbare groepen in de samenleving tegemoet kunnen worden komen. Door het doen van deze thesis heb ik geprobeerd om inzicht te krijgen in de manier waarop we omgaan met zorginstellingen in overstromingsgevoelige gebieden, op een ruimtelijke en sociaal niveau, met betrekking tot veiligheid voor overstromingen. Om dit te bewerkstelligen is een literatuurstudie uitgevoerd om inzicht te krijgen in het onderwerp en om niet-zelfredzaamheid te definiëren. Het Flooding Lizard Lizard programma is gebruikt om de blootstelling van de drie zorginstellingen te bepalen in het geval van een overstroming in Angeren of in Ijzendoorn. Interviews werden gebruikt om de kwetsbaarheid van de drie zorginstellingen bepalen.

Zelfredzaamheid wordt gedefinieerd als: alle handelingen die worden verricht door individuen en organisaties anders dan de hulpdiensten ter voorbereiding van, tijdens en na een watersnood ramp, om zichzelf en anderen te helpen en om de impact en de gevolgen van overstromingen te beperken. Er wordt van uitgegaan dat, vóór de start van de evacuatie, burgers zichzelf hebben georganiseerd op een zodanige wijze dat alleen mensen die medische (of psychologische) zorg nodig hebben, niet zelfredzaam zijn. De instellingen zijn kwetsbare objecten, maar ze zijn voorbereid op elk soort ramp. Ze hebben plannen waarin hun regelingen voor een tekort aan personeel, ruim aanbod van patiënten; sluiting van (delen van) de locatie, het falen van apparatuur, logistiek stagnatie, een uitbraak van besmettelijke ziekten in een instelling, en het verplaatsen van de patiënten worden beschreven. Elk van deze is noodzakelijk om zorg te kunnen continueren. En door het verzorgen van deze kunnen ze elk probleem strijden. Als er problemen ontstaan kan de GHOR hen te helpen door middel van haar contacten en 'paraplu' functie in de gezondheidszorg. Alle instellingen zijn in staat voor zichzelf te zorgen gedurende tenminste 72 uur.

Om goed te functioneren zijn alle zorginstellingen sterk afhankelijk van elektriciteit, water, personeel, telefoons, computers, logistiek en alle netwerken die hierbij horen. De werking van vitale netwerken is cruciaal voor het functioneren van een gebied, waneer deze falen kan maatschappelijke ontwrichting (slachtoffers / economische schade) ontstaan. Voorbereiding op een evacuatie kost tijd. Dit is zeker het geval bij een zorginstelling waar mensen minder goed in staat zijn om zelf dingen te doen. Dit bewijst het belangrijkste probleem te zijn. De instellingen zijn zich bewust van de gevaarlijke situatie die kan ontstaan als mensen vast komen te zitten in het verkeer, terwijl ze het gebied ontvluchten tijdens een overstroming. Alle instellingen toonden aan dat ze minstens twaalf uur nodig hebben om zich voor te bereiden op een evacuatie. In een acute situatie is dit niet altijd mogelijk. De grootste problemen zouden ontstaan indien problemen zich voordoen bij nacht aangezien op dat moment minder personeel aanwezig is. De kwetsbaarheid van kritieke infrastructuur moet goed worden opgenomen in de rampenplannen. We kunnen veel plannen maken, maar de beperkende factor is de mens. We zijn op de goede weg, maar we zijn er nog niet.

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Respondent 1	Responsible for facility management, personnel and finance i.a. in Kesteren
Respondent 2	Responsible for staff member facility services, everything that has to do with safety, refurbishments, renovations, Occupational Health Service (OHS) and MAAD i.a. in Tiel.
Respondent 3	Advisor in buildings and procurement i.a. in Culemborg
Respondent 4	Information contact in healthcare continuity at the MAAD

List of Abbreviations

Abbreviation	Acronym English	Acronym Dutch
ARC	Amsterdam-Rhine Canal	Amsterdam-Rijn Kanaal (ARK)
CRIAP	Coordinated Regional Incident Abatement Procedure	Gecoördineerde Regionale Incidentenbestrijdings Procedure (GRIP)
DHV	Engineering firm. Advisors for the sustainable design and use of our living and working environment.	Ingenieursbureau. Adviseurs voor het duurzaam inrichten en gebruiken van onze leef- en werkomgeving.
ENW	Expertise Netwerk Waterveiligheid	Expertise Network Water safety
EPR	Electronic Patient Record	Elektronisch Patienten Dossier (EPD)
ERT	Emergency Response Team	Bedrijfshulpverlening (BHV)
FRM	Flood Risk Management	Overstromingsrisicobeheer
GR	Group risk	Groepsrisico
HKV (Lijn in Water)	Research and consultancy services in the field of water and safety	Onderzoek- en adviesdiensten op het gebied van water en veiligheid
HSL	High Speed Line	Hoge Snelheidslijn
IPCC	Intergovernmental Panel on Climate Change	Intergouvernementeel Panel inzake klimaatverandering
IPO	Inter Provincial Consultation	Interprovinciaal Overleg
IVW	Inspectorate Transport & Public Works	Inspectie Verkeer & Waterstaat
LIR	Local Individual Risk	Lokaal Individueel Risico
MAAD	Medical Assistance in Accidents and Disasters	Geneeskundige Hulpverlening bij Ongevallen en Rampen (GHOR).
Min IenM	Ministry of Infrastructure & Environment	Ministerie van Infrasturctuur & Milieu
Min V&W (after 2010: Min I&M)	Ministry of Transport & Public Works	Ministerie van Verkeer & Waterstaat
MLFRM	Multi Layer Flood Risk Management	Meerlaagsveiligheid
MNP	Environmental Assessment Agency	Milieu- en Natuurplanbureau
NAP	Normal Amsterdam Water Level	Normaal Amsterdams Peil
NCBI	Non Congenital Brain Injury	Niet Aangeboren Hersensenletsel (NAH)
NIMBY	Not In My Backyard	Niet in mijn achtertuin
NWP	National Water Plan	Nationaal Water Plan
OHS	Occupational Health Service	Arbeidsomstandigheden (ARBO)
PHS	Public Health Service	Gemeenschappelijke Gezondheidsdienst (GGD)
RIVM	National Institute for Public Health and Environment	Rijksinstituut voor Volksgezondheid en Milieu
RLI	Councils for the Environment and Infrastructure	Raden voor de Leefomgeving en Infrastructuur
RWS	Department of Public Works	Rijkswaterstaat
STOWA	Foundation for Applied Water Research	Stichting toegepast onderzoek waterbeheer
TMO	Taskkforce Management Floods	Taskforce Management Overstromingen
TNO	Scientific research & consultancy for companies and government.	Wetenschappelijk onderzoek & advies voor bedrijven & overheid.
UVW	Union of Water Boards	Unie van Waterschappen
VNK	Safety of The Netherlands Mapped	Veiligheid Nederland in Kaart

1. Introduction

This thesis investigates to what extent the evacuation needs of vulnerable groups in society is being addressed in dike ring 43 in the Province of Gelderland, in the context of the operationalization of the third layer of the flood risk management policy package. The first chapter is an introduction in which the background of the study, the area in which the study takes place and the policy background are explained. Thereafter, the problem statement, objectives and research questions are presented.

1.1 Research background

1.1.1 Scientific background

Increasing problems

In 2010, more than 216 hydrological disasters (85.2% were floods) were reported all over the world, there were about 189 million victims. The occurrence of these disasters has increased by 20% compared to 2009 (Ramsey, 1994). The Netherlands is partly dependent on its neighbours for flood protection. The dependence of the Netherlands on foreign countries makes it particularly vulnerable (MNP and RIVM, 2004). The risk of damage and casualties by water will increase in the future. Extreme weather events will occur more frequently worldwide, and cause problems for residents, economy, ecology and cultural heritage (Van de Ven et. al., 2011). After the 1953 flood disaster, which claimed the lives of over 1,800 people, measures have been taken to protect the Netherlands against flooding from the sea or rivers.

Flood protection in the Netherlands

A flood is caused by the collapse of the flood defences that protect the area behind them. In the Netherlands, floods are often caused by the collapse of regional flood defences and dike breaches as a result of extreme river discharges, storm surge and combinations thereof (Kolen, 2010). Every flood has specific characteristics. As the predicted time and size differ and the course is determined by the geography of the land (Kolen, 2010). Because of the flood defences established after the flood disaster of 1953, the probability of flooding and thus the individual risk of death is greatly reduced (MNP and RIVM, 2004). In the Netherlands, the flood protection through prevention is interwoven with society. In the second half of the twentieth century, living behind the dikes has become so common that society hardly realizes how dependent the Netherlands is on these dikes. This makes our society more vulnerable in the case when the dike breaks through (Ten Brinke et al., 2008).

After the 1953 flood disaster, the Delta Commission laid the foundations for the current safety standards for protection against flooding by sea or river. In subsequent years, the government has also determined safety standards for flooding by rivers. These standards are then documented in 1996, in the Act of the Flood defences (Wet op de Waterkering) (MVW, UVW & IPO, 2009). The current legal standards for protection against (large-scale) flooding from the sea, rivers and lakes are largely based on the situation and demands prevailing in the sixties of the last century (Deltares, 2011a). The government, together with the Delta Program, wants to ensure that current and future generations are safe from flood hazards and that we have enough fresh water at our disposal the coming century (Zethof et. al, 2012). Therefore, a new concept was introduced in 2009: Multi Layer

Flood Risk Management (MLFRM)[1]. MLFRM is a concept that can be used to shape flood risk policy. In addition, it is possible to see if the aspirations are satisfied and whether the policy is cost effective. Last, MLFRM can support the administrative decision-making process (Zethof et. al., 2012).

Risk approach and focus on dikes

More than half of the Dutch population, approximately nine million people, currently live in an area that is so low that it can be flooded from the sea or the rivers (Annex 1). In this area, 65% of the national income is earned (Zethof et. al, 2012). Sea level rise, the increasingly intense rainfall and the increasing melt water from the Alps provide higher water levels along the coast and in the rivers (WMD, UVW & IPO, 2009).

The Netherlands has become considerably more vulnerable in recent years to the danger of a possible flood (RLI, 2011; MNP and RIVM, 2004). The high vulnerability of Dutch society is due to its dense population and highly developed areas located below sea level. The vulnerability to social disruption is still increasing. The economic risk is increased by the strong expansion of the invested capital. Also, due to population growth, the risk of large numbers of victims (group risk) has increased. Due to population growth and an increase in invested capital, there are more casualties and the economic damage will be greater (RLI, 2011; MNP & RIVM, 2004; Ten Brinke et al., 2008). When a flood would occur, there are greater consequences. This is exacerbated by the long-term soil subsidence, sea level rise, increased discharge of rivers and more extreme weather events. (RLI, 2011)(Figure 1.1). The current security policy therefore does not lead to the "safe and habitable the Netherlands" as it was originally intended after the 1953 flood disaster (MNP and RIVM, 2004).

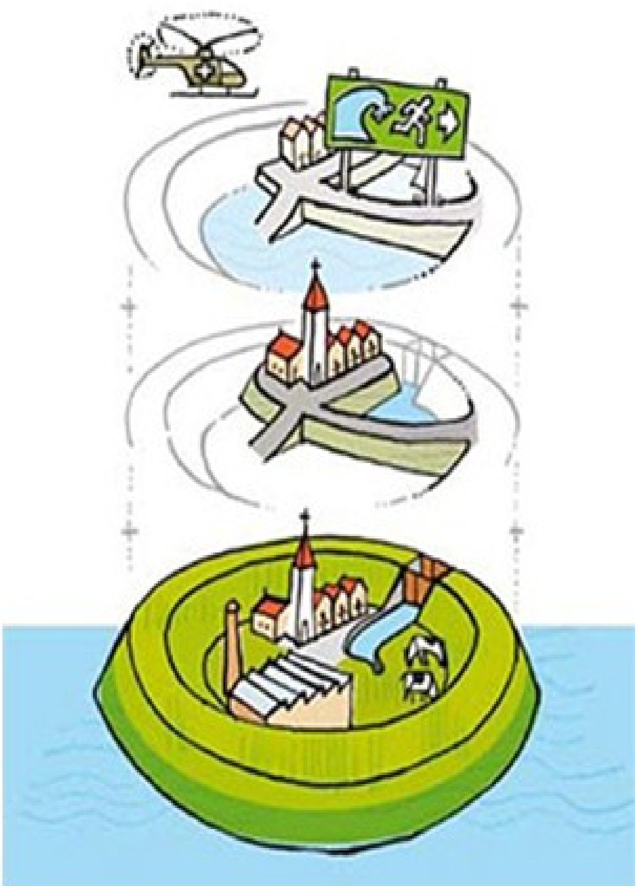

Figure 1.1: Three layers within Flood Risk Management (STOWA, 2011).

The primary flood protection in the Netherlands are the dikes. Are these dikes stable and high enough to protect the Netherland in the years to com? In recent years we have gained a better understanding of failure mechanisms that cause dikes to collapse, such as piping[2]. Also the knowledge to calculate flood risks (probabilities and consequences) has improved. As well as the (economic) methods necessary to sustain the level of protection (Deltares, 2011a). The (high) water safety policy is still focused on the monitoring and maintaining of flood defences to protect people.

[1] If the Dutch term (Meerlaagsveiligheid) is translated directly into English, this would be Multi-Layer Safety (MLS). However the concept of MLS is not known in such way outside the Netherlands. There, the term Multi Layer Flood Risk Management is used (MLFRM). Therefore this term will be used throughout this thesis.

[2] Piping is a phenomenon in which water seeps under the dike and a watercourse occurs (RLI, 2011)

(IVW, 2011). But is this policy justified? Do we have to continue to adhere to the welfare state or has the time come to try a different approach? How can we keep the Netherlands, both now and in the future, safe from flooding? (WMD, UVW & IPO, 2009).

Within spatial planning often many stakeholders and uncertainties regarding the future are involved. The solutions may include structural and non-structural measures. These measures can be taken at different levels. Measures may also differ to local conditions, political affiliation, culture and local governance structure (Van de Ven, 2011). The goal is to jointly find a solution where every stakeholder agrees. In order to integrate the risk of flooding effectively as a planning variable, a transition in which both spatial planning and water management are more integrated is required to solve problems.

1.1.2 Policy background

The frequency and effects of flooding are ever increasing. Research (Klijn et al, 2010) has shown that continuation of the current policy will increase the damage and casualty risks by a factor 1 to 1.7, due to climate change and sea level rise. The flood damage potential is expected to grow by a factor of 1.9 up to almost 2.4 by 2050, due to increased value of existing and new construction (Klijn et al., 2010). This occurs specifically in the coastal region and the lower river area.

It is more and more recognized that solely technology and dikes will not provide the solutions that we need in the future (Herk et. al., 2011 & Zethof et. al., 2012). Authorities are aware that they cannot solely rely on their flood defence system (Ten Brinke et. al, 2008). It has been shown that dikes may be unstable (Hurricane Katrina New Orleans, 2005 and the breach in the dike by Wilnis, 2003). The height of the water level, the strength of the waves, instability of embankments (piping), drought and human error can cause dikes to fail. This is not properly taken into account in the current standardization system for primary flood defences (RLI, 2011). In the current policy is chosen to address the current bottlenecks through cost-effective measures which make the system more flexible and less vulnerable to extremes, without thereby blocking long-term ambitions and by keeping desired options open (Schultz van Haegen, 2013).

This is done using a still relatively new flood protection and mitigation strategy called MLFRM. Because MLFRM is relatively new, it is difficult to comment on, for example, applicability. MLFRM consists of three layers. The first layer is concerned with protection (building dikes), the second with spatial planning. The third layer of MLFRM wagers on a better organizational preparation for a possible flood (disaster management) (Zethof et. al., 2012). The primary focus is on improving the organization of disaster management, improving self-reliance and the additional aid resources (Kolen & Hoogendoorn, 2012). MLFRM forms a bridge between water management and spatial planning. MLFRM will be discussed more elaborately in chapter two.

There is a mind set in which it is assumed that disasters will occur, regardless of the level of preparation. And that this is something we have to live with (Archour & Price, 2010). It does not matter how much we try to predict and anticipate on it, the future will be uncertain to some degree. Also the policy agendas change regularly. Now, for example, is looked at a mix of 'doing everything with dikes' and 'room for the river' (Province of Gelderland, 2013). It is a sliding scale from just technical measures towards just spatial measures and everything in between. Policies therefore focus on reducing vulnerability, by taking measures in social and environmental systems to counter the negative effects of flooding (Keim, 2008).

The deployment of organizational interventions for existing resources in an existing environment can be done at a relatively low cost (Zethof et al., 2012). Consideration should be given to the planning process, exercises and development of knowledge. Specific examples include improving emergency planning, forecasting floods, improving self-reliance and deploying existing buildings as a place of refuge. These measures contribute to reducing casualty risks. The effect of these interventions is limited by the capacity of staff and infrastructure. (ENW, 2012). We need to take a better look at our laws and responsibilities to provide additional flexibility to citizens who have to deal with a disaster (Archour & Price, 2010).

Being prepared for recovery after a disaster falls under the realm of the government, insofar as the vital infrastructure and facilities are of national interest (RLI, 2011). Protection against a flood was previously expressed, by Rijkswaterstaat, in a probability of water levels exceeding the maximum protective height of the flood defences, rather than a probability of flooding, because the latter could not be determined with sufficient accuracy (Kolen, 2010). The probability of flooding takes into account a particular water level, together with other failure mechanisms. This enables the probability of flooding to be much lower or higher compared to the exceedance probability.

To protect the Netherlands, vulnerable areas are protected by a surrounding dike (dike ring). A dike ring, also known as a diked area, is an area that is protected from external water by a primary flood defences, higher grounds (e.g. Veluwe) or structures for water management, such as sluices and pumping stations. To each dike ring in the Netherlands, a flood frequency is assigned. This is based on the advice of the Delta Committee. The flood frequency is dependent on the nature of the threat (from the river, sea, or lake), the size and the importance of the area. It differs in the expectation that a flood can potentially take place from once every 250 years to once every 10,000 years. This depends on the number of inhabitants and the economic capital that this dike ring must protect. In the Water Act, it is stated that the flood defences have to be tested every six years for their hydraulic state. Such a periodic review is unique in the world (RWS, 2011a). When the current policy is continued, it means that we are working towards the protection levels per dike ring as laid down in the current standards (Deltares, 2011a).

1.1.3 Regional background

This research focusses on one dike ring in particular. Dike ring 43 (Figure 1.2) is located in the province of Gelderland and (to a small extent) in the province of South Holland. The Over-Betuwe is a gravity draining catchment area consisting of dikes along the rivers and basins in the central parts (Waterschap Rivierenland, 2007). At the northern side, the dike ring is bordered by the Lower Rhine (Nederrijn) and Lek, at the eastern side by the Pannerdensch Kanaal, and at the southerly side by the Waal and the Boven Merwede. On the westerly side, the dike ring is bordered by the Diefdijk, which connects the southerly Lekdijk with the Northern Waal dike. The Diefdijk is responsible for delivering the difference in safety between dike rings 16 and 43 (Provincie Gelderland, 2013). The inner area is intersected by the Amsterdam-Rhine Canal and the river Linge. The total length of the dike ring is 165 kilometres (RWS, 2011b). The main (residential) cores within the diked area are: Arnhem, Geldermalsen, Culemborg, Tiel and Elst (Figure 1.3). The dike ring is home to an estimated 220,000 to 250,000 people. The population density on average is higher in the east than in the west. Industrial sites and other high quality economic areas are part of the urban areas. Several major highways and railways (including the A2, A15, A50 and Betuwelijn) intersect the area (Provincie Gelderland, Min V&W & DHV, 2010).

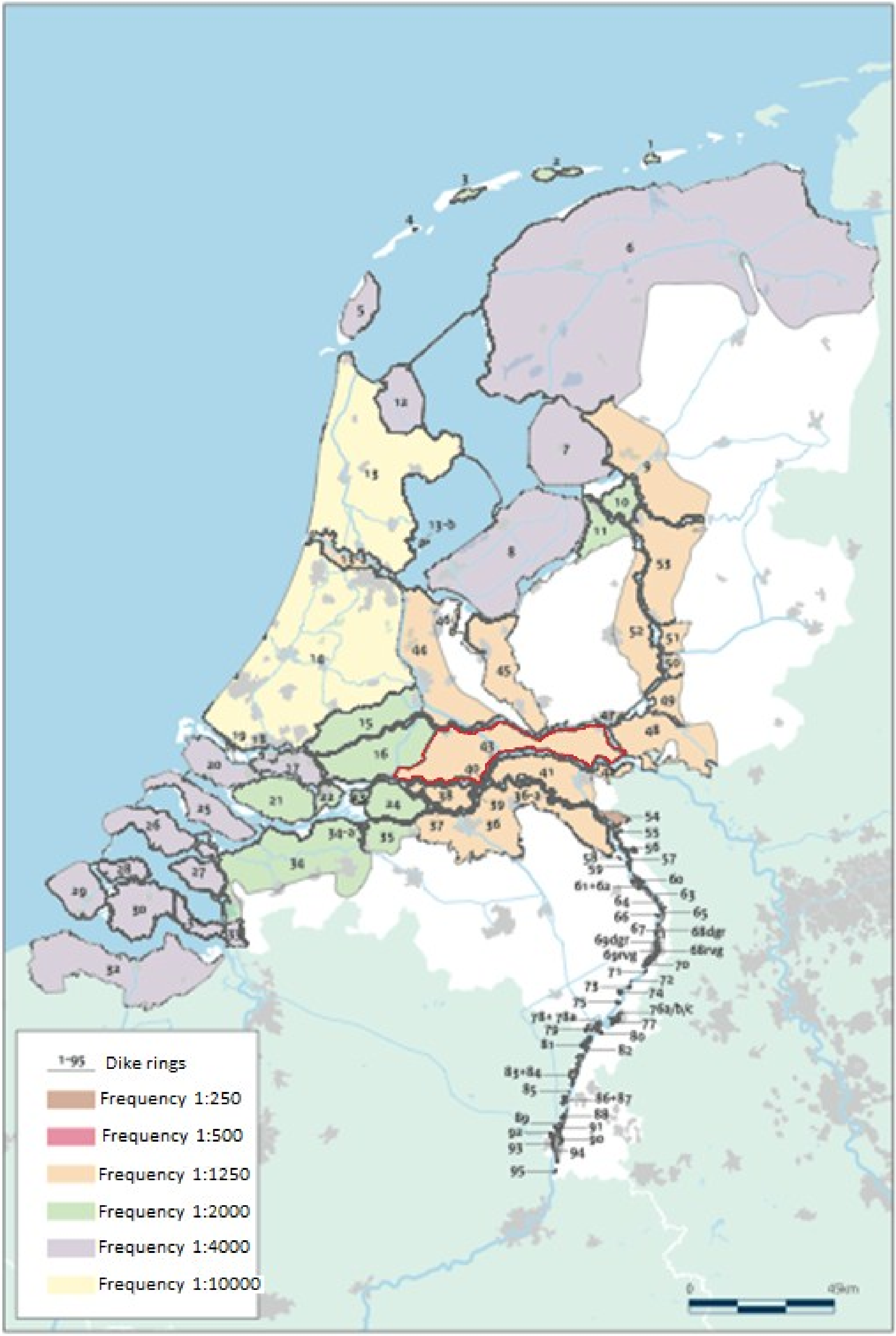

Figure 1.2: Map with a display of the dike rings in the Netherlands. Dike ring 43 is indicated by a red line (Source: Provincie Gelderland).

Figure 1.3: Project area and main (residential)cores (Source: Google Maps).

Dike ring 43 is a large dike ring with great differences in depth, reaching from +10 NAP[3] in the east towards slightly below NAP in the west (Figure 1.4). In the Flood Defence Act (Wet op de waterkering), for dike ring 43, a safety standard is adopted that corresponds with an exceedance probability of 1:1250 per year. This means that the dikes have to withstand high river discharges that occur once every 1250 years (Provincie Gelderland, Min V&W & DHV, 2010). Based on field characteristics, dike ring 43 is divided into five areas (Provincie Gelderland, Min V&W & DHV, 2010).

Subarea 1 is the easternmost part of dike ring 43 and is bounded to the west by the A50. It is the most densely populated part of dike ring 43 with parts of Arnhem and Nijmegen within the dike ring. In the future, the population density is further increased with the development of the City-Region Arnhem - Nijmegen. Within the dike ring this is the most elevated area. The A50 is the boundary between subareas 1 and 2. Subarea 2 runs from the A50 in the east to the Grebbelinie[4] in the west. Subarea 3 runs from the Grebbelinie in the east to the Amsterdam-Rhine Canal in the west. The characteristics of area 2 and 3 are broadly similar. Both are relatively low density areas with open countryside and villages that are generally close to the dikes of the Waal and Lower Rhine. In this area, no major urban extensions are planned (Source: Provincie Gelderland, Min V&W & DHV, 2010). It is expected that the population in the centres will slightly increase until 2050. The risk of damage and casualties in sub region 2 or 3 is considerably smaller than in sub region 1, this is primarily because there is less habitation and economic activity in the area.

Subarea 4 is bounded by the Amsterdam-Rhine Canal in the east and the A2 motorway in the west. In this area, the towns of Tiel, Culemborg and Geldermalsen are situated. Outside these areas, the area is sparsely populated and is characterized by open countryside. Unlike in subarea 1, not any major urban expansion is planned in this area. A slight growth of urban areas is provided, specifically

[3] The Normal Amsterdam Water Level (NAP) is the reference height to which altitude measurements in the Netherlands are related. A NAP of 0 meters is approximately equal to the average sea level.

[4] The Grebbelinie was a defence of the Dutch Water Line (Hollandse Waterlinie), a Dutch line of defence, based on inundation (intentional flooding of an area). The Grebbelinie ran through the Gelderland Valley from the Lower Rhine near the Grebbeberg in Rhenen along the Valleikanaal and Eem to the Zuiderzee, later the IJsselmeer. The Dutch Water Line lay east and south of the cities of Holland (Nowadays the provinces of North Holland and South Holland), was 85 miles long and 3 to 5 kilometers wide. The line stretched out from the island of Pampus (in the Zuiderzee) to the Biesbosch (in the provinces of South Holland and North Brabant) (Provincie Gelderland, 2013)

in Tiel. Subarea 5 is the most westerly part of dike ring 43 and is bounded on the east by the A2 motorway and to the west by the Diefdijk and Lingedijk. It is the least populated and lowest-lying area of dike ring 43. It is expected that the population in the centres will slightly increase until 2050. Because of the small population and the open landscape with few buildings, the property and casualty risks in this area are relatively low. (Provincie Gelderland, Min V&W & DHV, 2010).

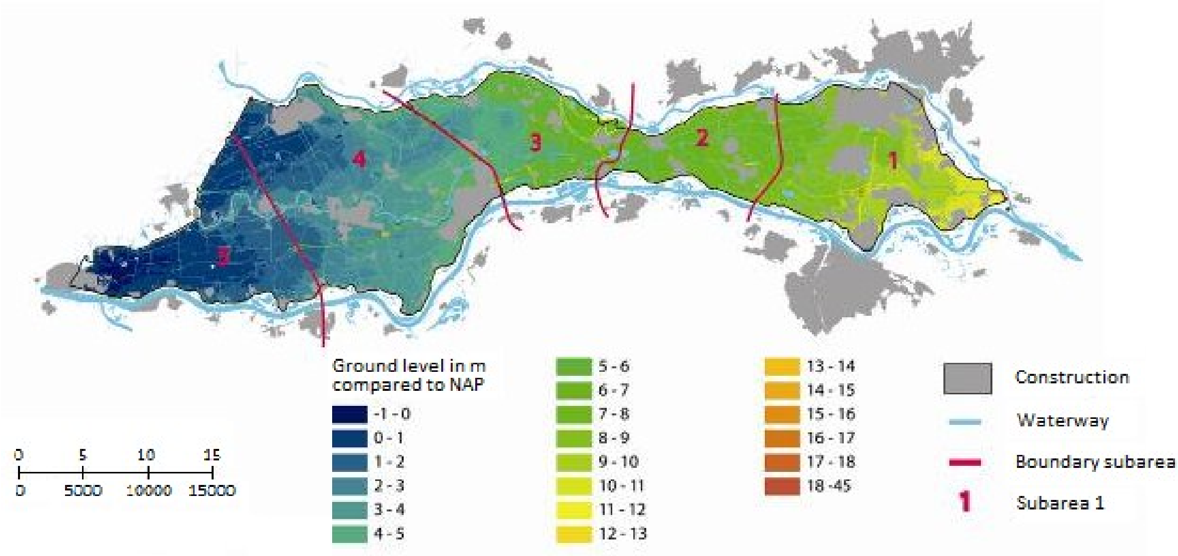

Figure 1.4: Ground level in dike ring 43 (Source: Provincie Gelderland, Min V&W & DHV, 2010).

Using Risicokaart.nl and GIS, it was possible to create a map on which all buildings used for domestic purposes and buildings for healthcare services are located (Figure 1.5). This figure shows that all of these buildings (except one) are located in residential areas.

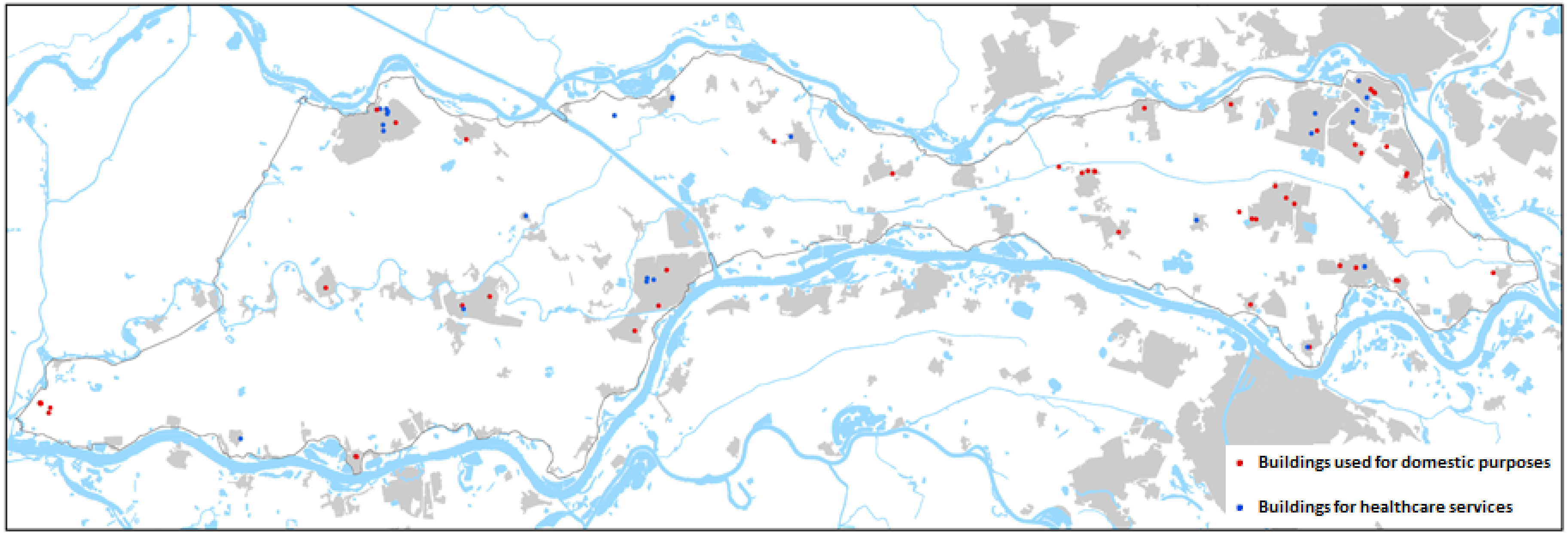

Figure 1.5: Overview of the buildings used for domestic purposes (homes, residential complexes for non-self-reliant people and places for the elderly) and buildings for healthcare services (clinics, hospitals and nursing homes) (Created using Risicokaart.nl and GIS by E. Lenselink & G. Perquin, from Provincie Gelderland in 2013.

1.2 Problem statement and research questions

In this thesis, the main interest is in the third layer, especially in the vulnerability of non-self-reliant people. The concept of MLFRM poses problems for potential evacuees that are not able to fend for themselves. Also, vulnerable locations like hospitals and nursing homes, where a lot of non-self-reliant people are situated in times of crises, are problematic in the concept of MLFRM. This type of evacuees and vulnerable locations are not yet looked into from the perspective of MLFRM. The focus of this research is on the position of non-self-reliant people in healthcare-institutions in MLFRM. Problems in MLFRM about this type of institutions are for example: the location of institutions and the situation in the surrounding landscape, access to infrastructure for evacuation and supply of vital resources, response times in case of flooding, etc. In order to gain insight in this topic, the concepts regarding vulnerability, exposure and self-reliance are used to look at three locations in dike ring 43 as an exemplary case

This study will investigate to what extent the evacuation needs of vulnerable groups in society is being addressed in dike ring 43 in the Province of Gelderland, in the context of the operationalization of the third layer of MLFRM. This study contributes to the decision making process about the operationalization of the third layer of the MLFRM policy package for flood mitigation and can inform key policy actors on how to accommodate the interests of vulnerable groups in society. Looking at the uncertainties described above and the things we do not yet know about MLFRM, the main research question is:

"What is vulnerability in the case of a flood and to what extent this is already taken into account in the context of evacuations of non-self-reliant people in healthcare institutions?"

- **Self-reliance**
  1. What is exactly meant by non-self-reliance and what does this mean for the people live at these locations where these healthcare institutions are located?
  2. Is there specific policy for these institutions and how this element is included in evacuation- and security plans?
- **Exposure**
  3. What is the course of flooding when a dike breaks, and how fast and up to which water level will these areas be flooded, specifically looking at infrastructure and the healthcare institutions?
- **Vulnerability**
  4. Where can you find the specific vulnerable functions and how are these spatially situated with respect to height, infrastructure and possible escape routes?
  5. What are the practical implications in the field of spatial planning and the buildings themselves?

1.3 Objective

There are three types of objectives in this study: scientific, societal and personal objectives.

1.3.1 Scientific

The main reason for this research is to contribute to the scientific debate on the contribution of the third layer. The Province of Gelderland started to investigate the applicability of MLFRM within dike ring 43 in 2010. The case of dike ring 43 gives me the opportunity to carry out my research within the current process and to experience the process. Province of Gelderland, Water board Rivierenland and the Safety Regions (Veiligheidsregio's) are also involved. The outcome of this research might show them which areas need more attention the upcoming years.

Many things surrounding MLFRM are unknown or unsure because the concept is so new. This complexity makes it very interesting for me to do research. Besides this, the concept connects spatial planning with water-management. The first being the subject of my major and the second being something I have become interested in.

Last, people who reside in healthcare institutions belong to the most vulnerable groups in society. It is important to know how is dealt with a possible evacuation of this group of people. To what extent we are prepared to bring them to safety and how this is done can give insight in the current situation and possibilities in the future. Next to this, this thesis might inspire someone to carry out a research in a more specific field.

1.3.2 Societal

The reason for this research is that MLFRM is considered a possible solution for the ever increasing complexity at flood protection and mitigation issues. Many interests are at stake. On www.waterforum.net, I found advocates and opponents of this policy package. Some believe that the first layer provides the solution. We should invest in dikes to prevent any harm from happening. Others believe that the second and third layer provide many possibilities to make the Netherlands a safer place. For example in areas with a low number of inhabitants, since the cost/benefit ratio is very high there in comparison to building dikes.

In this thesis I will try to understand the complexity of applying the concept of MLFRM to the safety of vulnerable features related to groups in society, and the consequences for policy making and planning. By interviewing the different stakeholders, I will try to gain as much information as possible within the limits of my research. Stakeholders may give different answers with different meanings and I want to try and make sense of this. I have to rely on how the stakeholders view the situation, looked upon from their background and history. Meanings, even when given subjectively, are always negotiated socially and influenced by social and cultural norms.

1.3.3 Personal

For the past four years, I have been studying spatial planning. Integrated water management plays a subordinate role. Because of my interest in this field, I am trying to gain knowledge by linking it to my thesis. I have done this already in my bachelor thesis, and now I am doing it again in my master thesis. The water related issues we are dealing with in the Netherlands pertain to the field of integrated water management. They are interwoven and interconnected. Both play a role at various scales and display many different factors. By doing this thesis I try to gain insight in how we are dealing with healthcare institutions in flood prone areas, on a spatial and social level, related to flood safety. By this I mean institutions whom have inhabitants or clients which are not able to fend for them-selves. Are they built in an area that is safe from flooding? If a flood occurs, can these people then be quickly evacuated? And how is this recorded in the current policy of municipalities and institutions? It is quite possible that my thesis raises more questions than it answers. But that is not a problem. In my opinion, this may lead to a wider range of possibilities to deal with the problems ahead.

When doing my thesis research, I am going to work on some of my learning goals. I will keep a diary while writing my thesis and when I am finished, I will reflect on my learning goals. These are:

- Writing a solid and sound theoretical framework for my MSc. thesis.
- Experience a professional working environment.
- Improve my scientific writing up to the point that it does not decrease the value of my thesis work.
- Learn to use more arguments for the statements I make. In my thesis, as well in discussions and meetings with my supervisor and professionals in the field.
- Gaining knowledge in the field of MLFRM and how water-management, flood protection and urban planning are connected.

1.4 Outline

This thesis continues with chapter 2, which deals with the theory, concepts and methodology which are used in this study. The research that has been done is presented in chapter 3. The results of the study can be found in Chapter 4. Chapter 5 examines the research through conclusions, the discussion and recommendations. The last chapter deals with the reflection on the objectives and the learning process (Chapter 6).

2. Theories, concepts and methodology

This chapter covers the theories, concepts and methodology used in this thesis. First, Multi Layer Flood Risk Management is presented, followed by crisis management and environmental planning (2.1). Secondly, there is an inventory of problems and solutions which are found in literature on the aftermath of Hurricane Katrina (New Orleans), the flood of Des Moines (Iowa) and the flood in Orissa (India). Together they serve as input for the interviews to draw on later. Next, the concepts that are important to this study are discussed; these are exposure, vulnerability and self-reliance (2.2). These concepts help focus my research. Thirdly, the methodology used in this thesis is described (2.3). This chapter is finished with a description of the data set that was used to carry out the study and how the data was analysed (2.4).

2.1 Principles in management and decision making

2.1.1 Multi Layer Flood Risk Management (MLFRM)

Multi Layer Flood Risk Management (MLFRM) is an approach where one tries to control the flood risk. It provides a policy strategy to address and mitigate the effects of possible flood events. MLFRM is composed of the possible measures which can be divided into three different layers. Reducing the chance of a flood and the prevention of flooding by focusing on for example dike reinforcement is embedded in the first layer. The risk of a flood event occurring, however, can never be completely eliminated. Therefore, the second and third layer are aimed at reducing the impact of flooding. The second layer is focused on controlling exposure and the spatial development of our country such as the provision of infrastructure and spatial location of residential areas, and the third layer is focused on reducing vulnerability and disaster response such as evacuations (Deltares, 2011a, Deltares, 2011b and Zethof et. al, 2012). The ratio of an acceptable risk in relation to acceptable costs is central here (Deltares, 2011a). What can, and what should be done and at what costs? At a certain point, an increase in security is no longer in proportion to the associated costs. Money is a scarce commodity, and out of every euro spent, maximum benefits are to be achieved (Figure 2.1) (Deltares & HKV Lijn in Water, 2012).

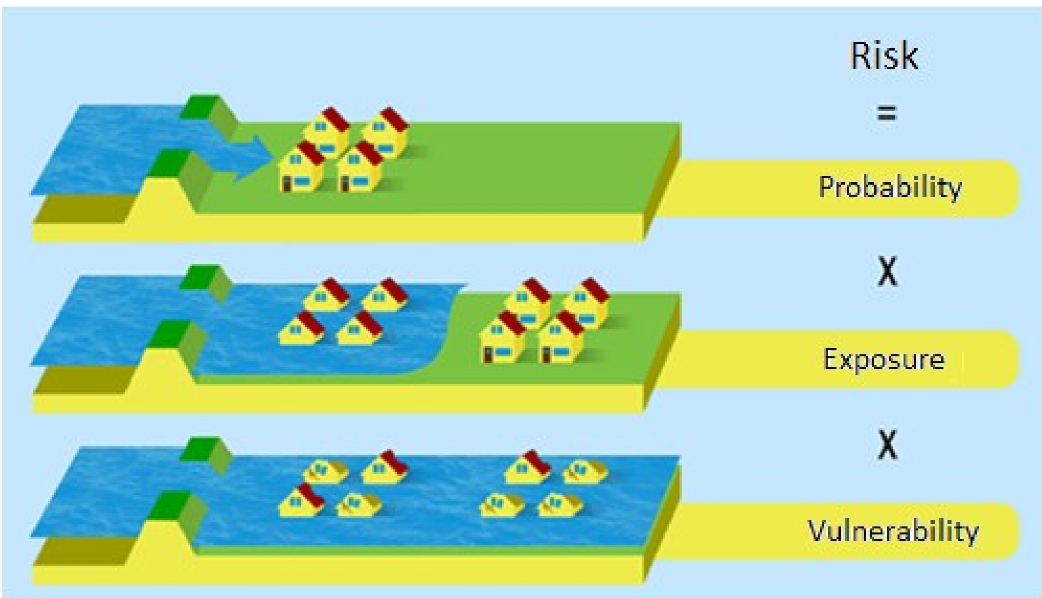

Figure 2.1: Flood risk (Source: RLI, 2011)

There are many differences with respect to risks of flooding between the provinces and municipalities in the Netherlands. Therefore tailoring is required to create a good, lasting solution. In practice, due to good cooperation, it proves to be possible to improve flood protection and mitigation in a certain area by means of a consistent approach to prevention, spatial planning and disaster control. MLFRM provides the scope (Atsma, 2011). Flood Risk Management is a social consideration that also includes the other area-specific criteria in the governmental decision making process. (Zethof et. al, 2012). Within the MLFRM methodology, a strategy is area-specific.

After determining the possible measures to be taken in the three different layers, the costs and benefits of these measures are to be identified (Deltares, 2011a, Deltares, 2011b and Zethof et. al, 2012). For this, a cost-benefit analysis is performed for the area-oriented strategies. In this way, it becomes possible to see what benefits are generated by which measures and at what costs. Besides the costs, the spatial quality, cultural history, feasibility etc. are equally important for the analysis (Zethof et. al., 2012). This enables for example municipalities and water boards, to make a weighted choice for a certain strategy without a single focus on costs. The goal is to gain insight in to what extent we are able to meet the challenges at hand.

The focus is on the first layer, with layers two and three being complementary (Zethof et. al., 2012). The first layer cannot be replaced by measures in the other two layers. However, it is possible to broaden the strategy by using the possibilities that exist within these two layers (Ten Brinke et. al, 2008). Within MLFRM not only "hard" technology and dikes (layer 1) are considered, but also to the 'soft' spatial planning (layer 2) and the possibilities for evacuation (layer 3). It is possible to take structural and non-structural measures to anticipate on or to prevent a disaster at a local, regional and national scale. Structural measures are 'hard' measures (such as dikes) and these try to reduce risk and damage by flooding. Non-structural measures are 'fixed' (potential escape route) or 'loose' (exercise for evacuation) and these are trying to fill the gaps which cannot be guaranteed by structural measures (Van de Ven et al., 2011). A combination of these measures and measures at different scales can be used to protect the Netherlands against flooding. The concept of MLFRM serves more as inspiration and background. The focus of this research lies on the third layer with consideration of the third layer.

2.1.2 Crisis management in the third layer

A disaster can be defined as "*a serious disruption of society that causes great human, material, economic or ecological damage which exceeds the ability of the affected society to cope using only its own resources*" (Keim, 2008: 508; Archour & Price, 2010: 265). To assess the effectiveness of flood risk management policies, a safety chain can be used (Figure 2.2). This chain contains five phases, namely pro-action, prevention, preparation, response and recovery (Ten Brinke et. al, 2008) which can be linked to MLFRM. Flood risks can be reduced by: reducing the chance of flooding (1st layer), limiting exposure (1st and 2nd layer) and limiting vulnerability (2nd and 3rd layer) (Deltares, 2012). The risk is equal to the probability of a flood multiplied by the impact of that flood. The risk can thus be reduced by taking probability abatement measures or consequence reducing measures. Probability abatement measures are preventive measures in Layer 1; Effect reducing measures aim at limiting damage and people (victims) behind the barriers by developing sustainable spatial planning (layer 2) or improving disaster management (layer 3). This is illustrated in Figure 2.2.

Figure 2.2: Reducing risks in cold and hot phases (TNO in Deltares, 2012).

Many schemes are based on a risk approach, in which the flood risk is the product of hazard * exposure * vulnerability. In this equation, the hazard is the probability that a flood occurs (Oosterberg et al., 2011: 22-23). Exposure means: Capital and population in flood risk areas that are thereby subject to potential losses. Vulnerability means: The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. (TNO in Deltares, 2012). In crisis management using MLFRM, the third layer should only be activated once the first one fails (TNO in Deltares, 2012).

The effects of the third layer in MLFRM, disaster management, affect the consequences of flooding. Through disaster management, more people can be brought to safety (greater part is preventively evacuated), self-reliance can be increased (limiting number of victims) and some damage may possibly be prevented (evacuation of animals and portable goods) (Kolen & Kok, 2011). In the analysis, the effects of disaster management (and self-reliance) are expressed in terms of: Another evacuation fraction: more people will be able to reach in a shelter or a safe destination outside the area, and Mortality rate: because people take better measures or are better prepared, it is expected that a percentage of victims will be lower. Damage Reduction: the economic damage decreases through measures. Relatively little is known about this effect (Kolen, Zethof & Maaskant, 2012).

Medical Assistance in Accidents and Disasters (MAAD)

An evacuation can be defined as an immediate relocation of groups of people ordered by government (GHOR, 2009). A distinction can be made between horizontal and vertical evacuation. For horizontal evacuation, people are removed from the site and in vertical evacuation people go to higher floors (Aghababiab et. al, 1994). The purpose of an evacuation is to extract humans and animals to an immediate danger. An evacuation can be acute or preventive (allows more time for evacuation), and short (<24 hours) or long (> 24 hours) (GHOR, 2009). In the Netherlands we have 25 safety regions. Each safety region is an area which brings together several administrations and services with respect to tasks in the field of fire fighting, disaster management, crisis management, Medical Assistance in Accidents and Disasters (MAAD)[5] and maintaining public order and security.

Within the safety region, the emergency services operate according to the Coordinated Regional Incident Abatement Procedure (CRIAP)[6]. When an accident takes the extent of a major emergency or disaster, the emergency services extend from the normal emergency services to the emergency response organization. The CRIAP procedure consists of four phases, CRIAP stage 1 to CRIAP stage 4. The CRIAP regulation describes the powers and responsibilities within the various CRIAP phases (GHOR, 2009). The CRIAP procedure will only be put into effect if there is a situation that goes beyond the normal daily routine. Duties and responsibilities of the MAAD are up-scaling and management of medical assistance in disasters, transporting bedridden clients, ensuring care under special conditions throughout the medical chain (meso-continuity of care) and organizing medical supervision in the reception location of the municipality and (after) care of victims and responders (GHOR, 2009).

In the "*Guideline evacuation healthcare facilities*[7]" of the MAAD is described what the tasks of the various organizations are. The municipality is responsible for informing residents, relatives and staff of the health institution, enabling transportation companies to move residents, the process of reception and care from the 1st emergency location onwards, registering residents at the shelter and providing basic necessities (meals, drinks, blankets and medicines) (GHOR, 2009). The regional commander of the fire brigade has the operational management lead in an emergency / disaster unless the mayor decides otherwise. Furthermore, the fire department responsible for the source- and impact control and tasks within the emergency response directly related to evacuation. This can include rescue of victims, making areas, roads and land accessible and passable, control of the building on stragglers and taking care of logistical provisions for aid workers (GHOR, 2009). The displacement (vacation / evacuation) of the population is the responsibility of the police, hereby there is close cooperation with the municipality, MAAD and fire department. In addition, the police is responsible for regulating traffic, law enforcement and surveillance of cleared buildings (GHOR, 2009).

The healthcare facilities need to continue the care for residents / clients at times of a disaster. Continuity of care is all about ensuring the care to the resident / client. Care must always be continued, even under special circumstances. Healthcare facilities have an efforts obligation towards each other to make capacity available. They assist each other in reception capacity to house residents at a fellow institution. In addition, a healthcare institution must ensure that client data and records are made available and transferable. A doctor makes a transport selections based on the health needs and the way of transport needed. Based on this indication, it can be determined to which reception location the resident / client / patient can be transported. Accompaniment during transportation is provided by employees of their own healthcare facility. The staff associated with the affected institution takes care of the care of the residents at the shelter locations as much as possible. In case of prolonged evacuation, the healthcare institution bears its own responsibility for the redemption of its employees (GHOR, 2009).

[5] In Dutch: Geneeskundige Hulpverlening bij Ongevallen en Rampen (GHOR).
[6] In Dutch: Gecoördineerde Regionale Incidentenbestrijdings Procedure (GRIP).
[7] In Dutch: Leidraad evacuatie zorginstellingen (GHOR, 2009)

The safety chain describe earlier (figure 2.2) is also used by the MAAD. In pro-action, the elimination of risks comes first. In prevention, the imposition of measures is key. Preparation is about preparing for combat, including care continuity. Repression is all about effectively responding to incidents/disasters and aftercare for victims and relief workers.

Emergency Planning in the third layer

Traditional approaches to risk management were designed for simple linear systems in relatively stable environments and are inappropriate for complex, dynamic and interdependent systems (such as hospitals) in unpredictable environments (Chow, Loosemore & Mcdonnall, 2012). Emergency plans often focus on emergencies outside the hospital causing a large current of injured (Peters, 1996). The hospital itself can also be directly or indirectly affected by a disaster. Disasters can be internal, for example power failure, water loss, chemical accident fire, explosion, loss of medical gases, violence/bomb threat, inability of staff to reach the hospital, loss of telecommunications or elevator emergencies. But the causes can also be external, for example an earthquake or a flood (natural causes) or transportation issues or terrorism (manmade) (Phalkey et al., 2010).

External causes, natural or manmade, may directly or indirectly affect a hospital. The causes of an internal disaster are versatile. An internal disaster means that the daily routine of a hospital is disturbed. An effective emergency plan can only be made where all of the causes are considered separately (Aghababian et al., 1994). In a health system, six pillars are of importance. These are the provision of services, healthcare professionals, information, medical products, vaccines and technologies, financing, and stewardship (Phalkey et al., 2010). By including all six pillars in an emergency plan, care during disasters can be continued. The emergency plan of a hospital should take into account disasters that can take place as a result of flooding. Specifically since this event may seriously damage the functioning of a hospital and its ability to treat patients (Aghababiab et. al, 1994; Peters, 1996; Phalkey et al., 2010).

It is normal that during a disaster not everything proceeds as orderly and appropriate as in a normal situation. However, it is important to get back to the normal routine as quickly as possible. This can be done by having the emergency planning and disaster management in order and to deploy them as quickly as possible, and improvise where necessary (Peters, 1996). Good disaster plans, fast action and a good communication network are of great importance when a disaster strikes. In addition, managers must be able to quickly identify the critical needs and to arrange appropriate assistance (Ramsey, 1994). The emergency response plans that were at hand in Iowa, had only a short-term impact. Emergency managers had to improvise according to the progression of the flood. They cannot always predict what they will need at the time of a disaster. But it is important that they know where they can find the things they need. When an emergency occurs, it is important to be both prepared and be flexible. If we are not prepared, it is not clear what should be done and by whom, the efficiency is also at risk. When we are not flexible, we can not anticipate well to changing circumstances (Peters, 1996). It is important to notice that writing an emergency plan is not the same as being prepared for a disaster (Phalkey et al, 2008).

2.1.3 Spatial planning, relating the second and the third layer.

The environment is classified in the physical environment (natural systems, built structures and technological structures) and the social environment (individuals, groups of individuals, cultural, political and social systems) (McEntire et al., 2010 in Palliyaguru, Amaratunga & Haigh, 2012). The vulnerability of the socio-economic system is determined by the degree of change in the system when adaptation measures are taken in comparison to the situation where we would do nothing (Aerts, Sprong & Bannink, 2008). Vulnerability to floods depends on climate change, land use and social factors (Hutter, 2007). The vulnerability changes over time. Buildings and areas are aging or need to be replaced or redeveloped at any given time. This provides flexibility to adapt the urban area to new circumstances or insights (Van Herk et al., 2011). Developments in the area offers space for adjustments that reduce vulnerability. It is possible to reduce vulnerability through environmental planning.

In spatial planning, the layer approach is used in which space is divided into three layers: the occupation layer, the network layer and the substrate, each with its own characteristics and speeds of development. It is possible to inhibit the speed of new economic developments in flood prone areas (Hutter, 2007). Urban development and revitalization of the current opportunities may help to reduce vulnerability to floods (Herk, et. al., 2011). As the chance of flooding is greater, it becomes more important to situate principal- and regional components of the networks of vital functions outside the floodplains. Taking advantage of higher ground in the area for placing vital functions and buildings (Ruitenbeek, 2012). It may be noted that to assess the extent to which something is experienced as vulnerable is highly subjective (Aerts, Sprong & Bannink, 2008). Spatial planning is seen as a vital way to manage exposure and vulnerability towards flooding (Herk et. al., 2011). Here, however, little research has been done. Good land use planning and buffer zones are seen as the most effective strategies in order to deal with floods (Palliyaguru, Amaratunga & Haigh, 2012).

However, it does not seem to be that environmental planning is intensively and systematically used for long-term Flood Risk Management (FRM). For example, by reducing vulnerability by controlling developments in flood prone areas and by providing room in less dangerous areas (Hutter, 2007). In the Netherlands we have experience in the fields of water management and spatial planning. Both disciplines relate to public space, but are treated by different professionals (Herk et. al., 2011). Thus the flood risk is seldom included as a planning variable to reduce exposure and vulnerability. Planning for the long term must take into account these uncertainties in a dynamic environment (Hutter, 2007).

Conclusion

According to the theories spatial planning and water management are interconnected. In protecting the Netherlands against a flood, the focus lies on the first layer and it can not be replaced by the other two layers within MLFRM. Within this research it is important to focus on the third layer, but without letting the second layer go out of sight. The second layer within MLFRM contributes to the third layer. As shown in figure 2.1, the probability that a flood occurs, the exposure and the vulnerability determine the risk. The probability will be minimized for example by constructing dikes in the first layer. This leaves exposure and vulnerability open for research. This thesis is about non-self-reliant people, therefore it is important to know what is understood by self-reliance. Exposure, vulnerability and self-reliance are important concepts which require a deeper understanding before carrying out this research. Therefore these will be introduced in the next chapter.

2.2 Concepts

Risk is defined as "*probability x effect*", and effect is broken down into exposure and vulnerability (Risk = probability x exposure x vulnerability). These components say something about the probability of flooding due to the collapse of a dike, but also about the progress and consequences of flooding. The speed at which people and goods are exposed to water and the depth of the water after flooding determine the risk and in what areas damage will occur. The vulnerability of people and property also determines the extent to which actual damage and casualties will occur (Figure 2.3). (Ten Brinke et al., 2008; RLI, 2011). Oosterberg, Van Drimmelen & Van der Vlist (2005 p. 22) state that "*Flood risk = hazard * exposure * vulnerability*", wherein "*Hazard = flood probability*", "*Exposure = capital and population in flood risk areas*" and "*Vulnerability = unpreparedness for a disaster and its consequences*". Exposure and vulnerability keep coming back in these equations. That is why it is important to gain more insights in these concepts.

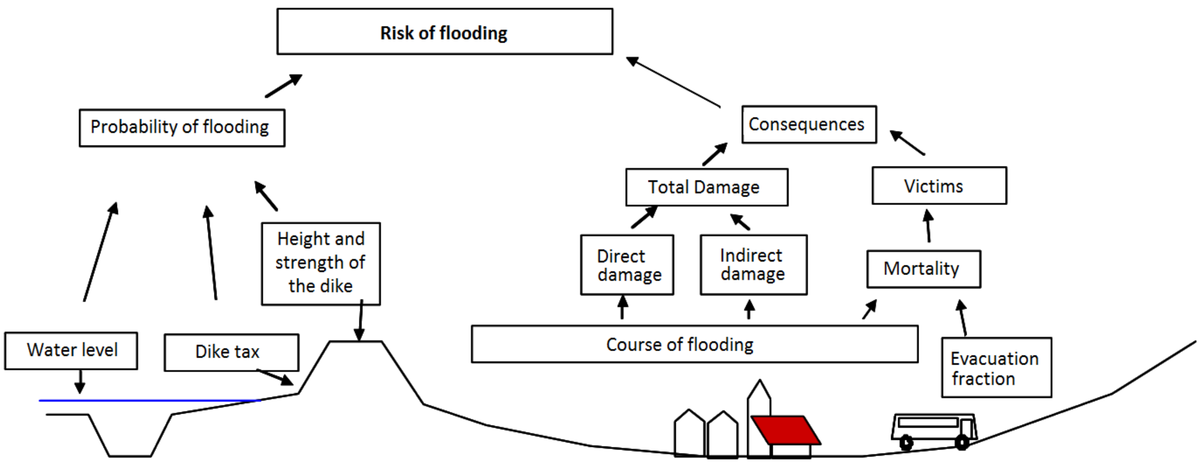

Figure 2.3: Factors that determine the risk of flooding. (Source: Deltares & HKV, 2012)

To get an image of which problems could occur during a flood, reports from hospitals and their experiences during floods have been used. The green boxes contain experiences of different hospitals during floods. These provide a unique insight into the potential problems that might arise.

2.2.1 Hospitals and disasters

When one thinks of a disaster, one often thinks of a lot of damage and large numbers of victims. Healthcare institutions form a separate group with difficult challenges when there is a disaster. They are responsible for the care of the most vulnerable people in society. During the crisis in 2005 after Hurricane Katrina, hospitals were part of the problem and the solution. In New Orleans, care for these people continued during and after the hurricane hit (Gray & Hebert, 2006). However, when evacuation was necessary this was one of the greatest challenges ever since it brought additional difficulties for these institutions. During a disaster it is increasingly difficult for a hospital to respond appropriately. Because of the disaster there are more sick and wounded, and more new patients will arrive while the resources are scarce. By taking precautions within the healthcare institution, the impact on the population will be reduced (Gray & Hebert, 2006; Peters, 1996; Ramsey, 1994).

In New Orleans the infrastructure was destroyed by the water. The electricity was out, water was not drinkable, the sewage was no longer usable and hospitals were difficult to reach because roads were under water (Gray & Hebert, 2006). The Iowa Methodist Medical Centre and low-lying areas were suddenly flooded by water. The hospital had no access to electricity, water, telephone and computer communications. Roads were forced to close, and the water treatment plant and major electrical distribution systems were unusable (Ramsey, 1994). The 1993 Midwest floods caused a loss of energy and telecommunications and a lack of potable water which is needed to provide appropriate care (Peters, 1996; Archour & Price, 2010). The flood caused substantive property damage, power outages, disruptions in the communication system, main roads had to be closed, the water supply of the city got polluted and thousands of people were forced to evacuate (Peters, 1996). In 2007, England had to deal with floods. There were water shortages because the water became polluted and there were no alternative water sources available. There were disturbances in the electricity and telecommunications. Amenities were inaccessible and some medical services could not be continued (Archour & Price, 2010). In 2008, a flood in Orissa (India) devastated the area and the health care in Jagatsinghpur (Phalkey et al., 2008).

Conclusion

Global climate change will increase the probability of extreme weather events such as heavy rainfall which may cause flooding. The effects of a flood on health care are twofold (Keim, 2008). The direct impact is causing damage to the infrastructure and buildings. This provides secondary disturbances, such as the hospital staff which is unable to reach the hospital (and colleagues with a burn-out) or because supplying cannot take place (Phalkey et al., 2008). Healthcare facilities are specifically vulnerable to failures such as in lighting systems, communications technologies, computer systems, heating and cooling systems, water supply and filtration, food storage, refrigeration, operating theatres and alarm systems.

2.2.2 Exposure

Exposure entails whether a system is subject to change or not (IPCC, 2007 in Aerts, Sprong & Bannink, 2008). In order to determine the exposure of healthcare institutions towards floods, it is important to define the susceptibility towards flooding. The exposure of numbers of people or property towards a flood is determined by the distribution of water within a diked area after a (local) flood defence has succumbed, the so called flood pattern. The number of victims of a flood is determined by the mortality and the ability to evacuate. The mortality rate is the probability that a person dies as a result of the occurring flood characteristics and flood pattern (Zethof et. al, 2012). The greater the percentage of preventively evacuated people, the less people is left behind in the area which can be exposed to the flooding characteristics.

When a flood takes place, then there is a difference between the damage which is caused by the height of water and damage caused by the velocity of the water. The depth of a flood is important for the possible damage. Next to the floodwater depth, a flood also exerts hydrostatic (pressure exerted by standing water) and hydrodynamic forces (e.g. rate at which water flows and / or debris in the water) on a building, which could cause the building to get damaged or even collapse. The size of the hydrodynamic force depends on the velocity, depth, mass density of the water, and the geometry of the building. In case of a flooding from a river, the speed of the water can increase the damage by an additional factor of over 100% compared to stagnant water (Nadal et al., 2010).

Mitigating measures can prevent or limit the exposure of the population to the flooding (Keim, 2008). Measures in flood risk management comprise actions which reduce the extent to which people and objects can be affected (RLI, 2011). The early detection of possible flooding and taking measures against it can greatly reduce the social and economic damage (Ramsey, 1994). It is possible to reduce the exposure of infrastructure towards natural disaster by for example, constructing elevated roads. The main strategy for dealing with flood risk management is exposure reduction, keeping the people away from the floods (Oosterberg, Van Drimmelen & Van der Vlist, 2005). Examples include reducing the number of affected people and objects by establishing a barrier (like a dike) and averting people and objects in areas prone to flooding.

Conclusion

According to the theory, it is important to determine the flood pattern. How deep the area is flooded, how fast the water flows and how fast the water rises determines the exposure of the area. These four points are used in flood models, which can in turn be used to determine the exposure of dike ring 43.

2.2.3 Vulnerability

The occurrence of a flood does not have to mean that a disaster will unfold. Whether a flood turns into a disaster depends on the interaction between the degree of exposure and the vulnerability (Keim, 2008). The vulnerability is determined by the degree to which a system is susceptible to adverse effects, and its ability to adapt to the changing conditions (Van de Ven et al, 2011). This is in line with Keim's (2008) definition wherein vulnerability to natural disasters has two sides: the degree of exposure to dangerous hazards (susceptibility) and the capacity to cope with or recover from disaster consequences (resilience). Not only people, but also the manmade structure in the area, such as roads, water and sanitation, are vulnerable to flooding (Palliyaguru, Amaratunga & Haigh, 2012). Vulnerability depends among other things on the site selection, chain dependence in telecom / ICT and the National Transport Network (Ruitenbeek, 2012).

Vulnerability is a complex concept. People's vulnerability to flooding depends on social, economic, health, and cultural aspects (Keim, 2008). McEntire et al. (2010) see vulnerability as the product of four components: risk, sensitivity, resistance and resilience. According to Van de Ven et. al (2011) there are four capacities within a complex system in order to reduce the vulnerability, namely the threshold capacity, coping capacity, recovery capacity and adaptive capacity. These can be linked to each other and to Oosterberg, Van Drimmelen & Van der Vlist (2005: p. 23) who see vulnerability as "*unpreparedness for a disaster and its consequences*" (Table 2.1).

The theories presented in this paragraph differ from each other, but they are not far apart. Three of these theories focus on the risk of flooding, two pay attention to the resistance we have to offer. The resilience and vulnerability come forward in all theories presented. The key is to also look at how we have to deal with the consequences of a flood and how to reduce these. A distinction can be made between vital networks and vulnerable objects. Vital networks are those that cause great extensive damage and effects in society due to loss of their services (Oranjewoud & HKV, 2011). Vulnerable objects / functions have many potential victims, such as hospitals, healthcare facilities, etc. but they can also be installations like power plants which can cause consequential damages and environmental risks in an impending flood. Vital objects where care is provided get pinched in a flood due to for example loss of electricity, staff shortages and logistics (Oranjewoud & HKV, 2011). How vulnerable people in healthcare institutions are also depends on the networks connected to these institutions (external factors), and how well management is organized (internal factors). In this thesis, not the entire concept of vulnerability will be treated. Only the vulnerability of healthcare institutions and its inhabitants and networks will be taken into account.

Table 2.1: Summary of important concepts in relation to vulnerability.

Mc Entire et al.	Keim	Oosterberg et al.	Van de Ven
Risk		Floodrisk	Threshold
Sensitivity	Susceptibility	Hazard	Adaptive
Resistance			Coping
Resiliance	Resiliance	Exposure	Recovery

Vital Networks

Infrastructure

A natural disaster such as a flood exerts mainly physical force to the fragile infrastructure resulting in damage. By the damaged infrastructure, the impact of a flood is transferred to the associated industries and communities in accordance with their interrelationships (Hastak et al., 2009). The National Transport Network is for safety reasons constructed in such a way that the primary components of open installations are situated at 2.50 meters above ground level and higher, this makes them not directly vulnerable in terms of water level (Ruitenbeek, 2012). Closed installations, however, are also situated lower and are not per se water proof. This also applies to secondary components for security / signalling / control which are mounted at a lower level. Making it possible to lose the functions of the transmission grid. Both transport to the Regional Transport and Distribution network as by transport in the National Transport Network may fail (Ruitenbeek, 2012). Foundations of for example roads are not designed for large flow velocities of water. The foundations of objects in the immediate vicinity of dikes will be undermined in the event of flooding (Ruitenbeek, 2012). The transmission grid has a high degree of redundancy, which reduces the system vulnerability of the transport network (Ruitenbeek, 2012).

Inaccessibility is often a major problem after natural disasters like a flood (Archour & Price, 2010). The delivery of goods often stops even before a flood actually occurs. After the flood, ordinary deliveries can get completely disrupted by damaged infrastructure. Authorities should recognize and prioritize the need for goods by hospitals (Gray & Hebert, 2006). In order not to be completely dependent of the supplying companies, it is important to have access to stocks and alternative suppliers (Archour & Price, 2010). It is advisable for healthcare institutions to be self-reliant for at least a few days and impose an emergency supply of essential drugs and supplies, but there is a possibility it will run out. This occurs for example through a sudden increase in patients or when deliveries are disrupted by damaged roads (Ramsey, 1994; Phalkey et al, 2008). It may also be that the staff cannot reach the hospital due to flooding. This problem is magnified as more victims arrive and the disaster lasts longer. It is possible to think of alternative ways to get the staff the hospital, for example by boat or by helicopter.

The system of hospitals in the Netherlands is organized in such a way, that there is a slightly geographical distribution of health care. The health care in the one hospital, can therefore in principle, be taken care of by other hospitals. Basically, patients can make use of different hospitals. But when a hospital fails due to a flood, the pressure on the still functioning hospitals in the area substantially increases.

Energy

Because of technological development, there are more and more systems in use that rely on electricity. It was difficult to provide proper care when the electricity went out. This includes the use of monitors, lighting, heating, elevators, dialysis machines, lab- and X-ray equipment, ventilation machines and air conditioning (Gray & Hebert, 2006; Archour & Price, 2010). In order to be able to continue the work, it is important that a battery operated ECG and defibrillator are at hand. There should be plenty of flashlights present in critical areas such as operating rooms, elevators and stairwells. Reflective stripes on stairs and thresholds can prevent tripping (Aghababiab et. al, 1994).

Because of the flood in Iowa, the city's electricity stations came to be underwater. This led to power outages and loss of telecommunications (Peters, 1996). It was difficult to meet full electrical requirements throughout the hospital due to the shortage of water to cool the back-up generators (Aghababiab et. al, 1994; Phalkey et al., 2008). In New Orleans, even emergency surgery was done with little anesthesia and using a flashlight (Gray & Hebert, 2006). Seriously ill patients were transported up and down dark stairwells because the elevators were not working. Doctors made their rounds using a flashlight because the lights were not working. Electrical equipment could no longer be used and the lab could not be used for testing. Patients in intensive care were ventilated manually and with improvised equipment. Patients needed their vital signs checked manually as well (Gray & Hebert, 2006; Aghababiab et. al, 1994). Relatives were fanning patients some coolness for hours in blazing hot rooms because the air conditioning was not working. Also, people slept on the roof of the hospital to escape the heat and the stench (Gray & Hebert, 2006). Management of waste is difficult during a flood, since syringes and biological waste can cause problems for public health (Peters, 1996; Phalkey et al., 2008).

Information and communication technology

ICT has become an indispensable part of everyday life. This also applies to the primary processes of healthcare institutions. In the current situation, specifically the nodes of the telecom / ICT main network are vulnerable. These nodes are susceptible to failure of the electricity and are located at various locations prone to flooding (Ruitenbeek, 2012). Patient records are now digitalized and the administration of an organization resides 'inside a computer (Van der Kam & Reitsma, 2007). Both internal and external communication systems form the backbone of the disaster management systems (Phalkey et al, 2008). It is precisely the loss of communication that led to bigger problems in the hospitals of New Orleans (Gray & Hebert, 2006). Communication with the medical staff was a big problem.

Chaos during the flood was the main factor that hindered healthcare institutions to respond adequately. There was a lack of organization, information and leadership, thus no one knew what to do. The various departments worked independently and there was a lack of staff and competences within the team. In New Orleans, help was not coordinated with the result that hospital staff had to communicate with all companies and to beg them for help. Poor internal and / or external communication threatens the response to a flood (Phalkey et al, 2008). The lack of leadership during the flood had a negative impact on the decision making process. There was a communication gap between employees, but also between the different levels (state, district, hospital). Telephone and other communication methods were out, making the staff feel like that the hospital was 'forgotten' (Gray & Hebert, 2006).

The dependence and vulnerability of ICT is a major concern. Many lessons from the experience after Katrina apply to the whole community. Thus, it is important to anticipate a disaster and that emergency plans are established in advance. There is a need for better communication, faster deployment of resources and better coordination of these (Gray & Hebert, 2006). To avoid panic, communication is essential. This is specifically true for people trapped in for example an elevator (Aghababiab et. al, 1994). It may occur that the telecommunication is lost partly or entirely. If this happens, it is convenient to have a backup for the pager systems. It is also advisable to have all the necessary numbers of suppliers on a list at hand (Aghababiab et. al, 1994). To be sure of the situation, contact with suppliers and city and state officials is required (Ramsey, 1994). Altogether, it is important that the continuity of ICT resources in healthcare institutions is ensured during a possible flood.

Drinking water

A flood may result in the loss of water pressure and suction devices. Loss of water pressure may also result in loss of sanitation, loss of sterilization devices, and an increased risk of fire (sprinkler system does not work) (Peters 1996). Water is also used to cool important operational and mechanical systems such as telephone and computer mainframes, air conditioners, lasers, emergency generators and the inability to develop x-rays.

The loss of potable water in medical centres in Des Moines Iowa had an impact on almost all phases of patient care and facility operations. The loss of water in Iowa even led to a special policy with regard to drinking water. Unnecessary admissions canceled or relocated, patients were centralized and water conservation measures were implemented. Immediately after the disaster, staff tried to conserve as much water as possible in buckets and basins in order to continue to provide vital patient care. In Iowa, a complex system of storage bladders, generators and pumps was established to store water and pump it into the sanitary system of the hospital (Peters, 1996). Due to the shortage of water, Des Moines had to find an alternative laundry site (Ramsey, 1994; Peters, 1996). After Katrina, plastic bags and buckets were used as toilet because the sewage system no longer worked (Gray & Hebert, 2006). A possible measure is to prevent unnecessary water usage by locking down 30% of the toilet facilities, sending away of visitors and dismissing patients (Aghababiab et. al, 1994).

The entire phone system in Des Moines medical Centre went down by the loss of cooling water. Luckily, mobile phones were present in key locations (Ramsey, 1994; Peters, 1996). Due to loss of water, unnecessary surgeries were canceled and it was no longer possible to sterilize (steam) instruments. This was solved by sending the instruments to surrounding hospitals and after, establishing the emergency water supply, by using the sterilization device once a day. The food and drink ran out. Therefore, the staff brushed their teeth and they fed each other with IV fluids. Opportunities for kidney dialysis went into trouble since these systems use a lot of water, to save water portable systems were used since these are more economical.

The kitchen in the hospital in Des Moines (Iowa) was used to boil water and for distributing bottles of water. Menus were adapted and disposable paper products were used to conserve water. A cold-food plan was used to save water and energy. Ice machines, soda machines, refrigerators and freezers were disabled (Ramsey, 1994; Peters, 1996). Also there was risk of infection because staff could not wash hands; this was solved by helping each other and using water bottles (Peters, 1996).

Water is a vital element for human survival. It pays off to store water for emergencies (Aghababiab et. Al., 1994; Ramsey, 1994; Peters, 1996). Plans concerning potable water must include measures about what to do when water is no longer safe for consumption. This includes ways to obtain purified water, informing people and shutting down and sealing valves, ice machines and drinking fountains. Attention should also be given to portable toilets when the sewage no longer works (Ramsey, 1994; Phalkey et al., 2008; Welter et al, 2010).

Conclusion vital networks

The literature review has revealed that vital networks are truly of vital importance in the case of healthcare institutions. A loss of infrastructure, energy, ICT or drinking water can have disastrous consequences for the continuation of care. Therefore these should be looked into when making plans for a healthcare institution.

Vulnerable objects

Hospitals are important and vulnerable objects when it comes to flooding. But the flooding of other objects, such as prisons and homes for the disabled can cause many casualties as well (Ruitenbeek, 2012). If a hospital is flooded the consequences are disastrous. Virtually all amenities in a hospital fail. The implications for the care of patients are therefore high. The depth and duration of the flooding strongly influences the impact on a hospital (Ruitenbeek, 2012).

A flood can cause many additional patients because people become victims of the flood (Ruitenbeek, 2012). Hospitals are important landmarks for a sense of security, when these fail it may lead to major social disruption. At the time of a crisis, a hospital becomes a beacon of hope. People who seek help or refuge, then come to a hospital. These people also need water, food and sanitation. In addition, they constitute an additional burden in case of an evacuation. If Katrina ever strikes again, hospitals would refuse to shelter family and pets. To cope with the peak of patients, there are three essential components, namely personnel, supplies, and structure (Phalkey et al, 2008).

Personnel

The staff in a hospital provides the care for the patients. In order to make best use of staff and resources, it is important to train personnel in dealing with chaos and disasters with a large amount of victims (Phalkey et al., 2008). Thought should also be given to the care of children of staff (Aghababiab et. al, 1994). They are not able to fend for themselves and their parents may be needed at the hospital for a prolonged time. When a flood threatens, it is convenient to house available staff and family near the hospital if possible (Phalkey et al., 2008).

After the flood in Des Moines, staff had to find out what types of buses could be used to move patients, and none of the staff in New Orleans had experience with arranging boats. (Gray & Hebert, 2006). The staff can also become victims of the flood. In Iowa, a program was established to detect staff that had suffered large losses during the flood. To ease the work, to provide security and to reduce stress, a series of trauma meetings was held where employees could express and share their feelings (Ramsey, 1994). Employees who had suffered personal losses were actively supported by social and pastoral services (Peters, 1996).

Supplies

Hospitals are particularly vulnerable to failure of the pre-conditional facilities: the power and gas supply, water supply, wastewater facility, accessibility for staff, patients, suppliers or the ability to evacuate. The possibilities to use emergency generators are limited. Hospitals do have emergency generators, but these can only temporarily provide in a part of the required power, at least if they do not fail in the event of a flood (e.g. location in basement of hospital) (Ruitenbeek, 2012).

Spinal boards to transport people had to be taken from storage in another location. To transport the boards, a vehicle must be found which was high enough to drive through the water. Arrangements had to be made with the police to let the truck through. During Katrina, the staff struggled to protect stocks (specific drugs), to maintain relatives and keep clearance in the garage (many people thought their car would be safe there) (Gary & Hebert, 2006).

The Pan American Health Organization (2000) described a hospital as a hotel, an office building, a laboratory and a warehouse in one to show its complexity. The healthcare system is a complex system with an extensive network of buildings and health care services that work together in an efficient way. This gives every citizen the appropriate care when he needs to. Hospitals are totally dependent on energy (electricity and gas), drinking water, waste water disposal, the supply of food and medicines and the availability of staff; these are also the vulnerable points. A flood can disrupt this process at multiple points and lead to failure of the 'business process'. (Ruitenbeek, 2012).

Buildings

Most of this part is dealt with under the paragraph exposure (2.2.2). A flood also brings with it security issues. Nowadays, flammable and toxic substances, like lasers, anaesthetics and x-ray, are frequently used in hospitals. This and the fact that advanced medical equipment is more and more dependent on electricity creates a vulnerable and a potentially dangerous environment (Aghababian et al., 1994).

Patients had priority in Iowa. It was important that their safety and well-being were not compromised (Ramsey, 1994). Patients who were stable enough, were discharged and sent home (Ramsey, 1994; Gray & Hebert, 2006). Problems encountered were that the emergency rooms were relocated from the first to the second floor to escape to the water. Dead bodies were piled in a stairwell because the morgue was both full and inaccessible (it was located in the basement).

Conclusion vulnerable objects

The building itself is an important vulnerable object. This is the place where people reside and where care is provided. Constructing it in a specific location and in a specific manner can contribute to the safety of the people in this building. Personnel are of vital importance since they are the ones providing the care. The supplies they need to provide care should be available and accessible at all times because the staff can not provide care without these materials and supplies.

2.2.4 Self-reliance

Self-reliance is defined as: all acts performed by individuals and organizations other than the emergency services in preparation for, during and after a flood disaster, to help themselves and others and to reduce the impact and consequences of flooding (Helsloot & Ruitenberg, 2004; Steverink et al., 2011). It is assumed that, before the start of the evacuation, citizens have organized themselves in such a way that only people who need medical (or psychological) care are not self-reliant. People who are confined by the government are also included here. Children and elderly not in need of care in institutions do not belong to this group. They belong in the care of family members (self-reliance) (Helsloot & Ruitenberg, 2004). In the National Water Plan (Ministry of Transport, 2008) and the EU Floods Directive (European Parliament, 2007) a central role for self-reliance is assumed. "When a disaster like a flood occurs, the government cannot guarantee that every citizen can be saved immediately" (Ministerie van Binnenlandse Zaken en Verkeer en Waterstaat, 2009). The purpose of enhancing self-reliance can be defined as improving the abilities of citizens to save themselves or survive until they are rescued (Kolen, 2010). Realization and strengthening of self-reliance is primarily a means to improve safety (Steverink et al, 2011).

A disaster can have limited possibilities of self-reliance. First, self-reliance of the citizens can be limited as a result of circumstances. In the case of floods, escape routes are limited. Secondly, survival then largely depends on help from others. (Helsloot & Ruitenberg, 2004) Movements of emergency services can lead to further clogging of the logistics system (and therefore reduce the effectiveness of self-reliant behaviour). Preparing for self-reliance in the event of disasters is however possible because the risk of natural disasters is visible and finite in the eyes of the citizens (Steverink et al., 2011). If necessary, they carry out actions to protect themselves such as going to higher grounds or a shelter. Preparing for evacuation and the strengthening of this independence is therefore a meaningful activity (Kolen, 2010).

Non-self-reliant

An organization whose main task is nursing and providing care should, in the design of the emergency response services, take into account the (large) number of persons that is not self-reliant, for example by mental and / or physical disabilities. (Van der Kam & Reitsma, 2007; GHOR, 2009). Clients in organizations for nursing and care are generally less mobile and not always self-reliant. Some people are bound to a wheelchair or bedridden. So they are extremely vulnerable and need help when moving. From them, self-reliance cannot reasonably be expected in case of a flood. When disaster strikes, good transport measures for evacuation are of great importance. This is true not only for moving within the healthcare institution, but also for the reception area and transport to the reception location (Van der Kam & Reitsma, 2007). This is also established by law (Article 2:17 subsection D of the Working Conditions Decree).

Evacuation of non-self-reliant people

When a healthcare facility must be evacuated this is a major event. This because to residents and/ or patients have to be taken into account who are not self-reliant and may require special and intensive care. The evacuation of a hospital is a logistical nightmare. Because of the special requirements for the transport and destination of patients, it is more difficult to evacuate a hospital in comparison to for example a hotel. Escape routes should be made known in advance to avoid congestion and chaos (Aghababiab et. al, 1994). But in New Orleans, evacuation plans were not usable because of the floods (everything is arranged using the ground floor) (Gray & Hebert, 2006).

In New Orleans, hospitals were initially excluded from evacuation. This made that at the supreme moment, the network was overloaded and there were not enough vehicles available to evacuate all patients (Gray & Hebert, 2006). In all locations, staff had difficulty finding shelters to send patients to. There were also complications with moving bedridden patients as well as patients who were administered oxygen and IV medications (they were transported up and down stairs towards the boats) (Aghababiab et. al, 1994; Gray & Hebert, 2006). Staff in New Orleans had to classify patients by type, destination and mode of transport. For example, medications were administered to psychiatric patients and they were taken to a psychiatric hospital by bus. (Gray & Hebert, 2006). When a healthcare facility is surrounded by water, and must be evacuated nevertheless, it must happen by boat or helicopter (Gray & Hebert, 2006). This proved to be a problem in New Orleans, since the hospital staff was not informed of the coordinates of the landing platform of the helicopter (Gray & Hebert, 2006).

It is important that special measures are taken when a hospital is evacuated. The shelter facilities and shelters should be known and arranged in advance. This is specifically true for people with special needs such as patients. Thus, the priority should lie in evacuating patients who have a life threatening condition. The second category contains patients which are moderately unstable, for example because they just had surgery. The third category contains stable patients. When the area is evacuated, it is of importance to adjust the medical personnel that accompanies the patients to the necessary care (Aghababiab et. al, 1994). It is advisable to classify patients, for example by using coloured straps (Aghababiab et. al, 1994), this to identify the specific needs and/or medication. Being able to track patients, helps with the continuation of care, this is specifically true for babies and patients with Alzheimer's disease. It is also important to ensure that the patient and his medical records are not separated (Gray & Hebert, 2006).

Conclusion self-reliance

Self-reliant people are able to get themselves to safety in case of a flood, non-self-reliant people need help with this. Evacuation can become hard for self-reliant people as the infrastructure can not cope with the amount of people trying to leave the area. This also affects the non-self-reliant people. They depend on others and special arrangements for transport and shelter have to be made. Making their evacuation more difficult and complicated.

Conclusion

The resilience in health care is not only important for providing care, it also has a social, moral and ethical necessity because people rely on a hospital to always be accessible when there is an emergency (Archour & Price, 2010). Modern hospitals no longer focus on just caring for the sick and injured. They also try to contribute to preventive medicine and the development of better health care. New technologies create for example 'remote healthcare', allowing people to do much more at home (such as measuring their insulin and monitoring their heart rate). They do not have to visit the hospital but can simply send the data through the computer. This ensures that the complexity of the healthcare system and the impact of a potential disaster will only increase in the future (Archour & Price, 2010).

In emergency situations, care institutions are central when it comes to large numbers of casualties. The complexity and interconnectivity of the health care system are the main reason for its vulnerability. A typical healthcare facility is for its daily operation depending on the condition of the building, the availability and adequacy of personnel, equipment, medical supplies, and good accessibility (Archour & Price, 2010). Damage to one of these elements can disrupt the entire system.

Because it is such a major event to evacuate a healthcare facility, it is important to establish issues in the planning process preventively (GHOR, 2009). The guidelines should be connected to what is described in the municipal plans. In these plans, no specific attention is paid to evacuating groups of people with low self-reliance and / or dependence on medical equipment (GHOR, 2009). So this task rests with the healthcare facilities themselves. When a flood threatens, is an evacuation a logical step? In the case of a hospital, this is difficult to determine, even when the surrounding area will be evacuated. Where flooding will occur and how severe the consequences are is uncertain. This also applies to the time that one has to evacuate. The evacuation of a hospital is a complex operation. The economic and human costs are high as it is always dangerous, difficult and expensive to evacuate large numbers of critically ill patients. When the area is evacuated, it becomes difficult to get hold of personnel and vehicles. Also, all these fleeing people can block the escape routes. It has to be decided if it is worth to take these risks in the light of a possible evacuation.

2.3 Methodology

In this paragraph, the methodology used in this research is described. The figure below (2.4) shows the most important concepts and their links. The concepts in question became apparent in the literature review. In my opinion, this figure shows the complexity of the situation in in which healthcare institutions find themselves. It will also be used to draw up the interviews.

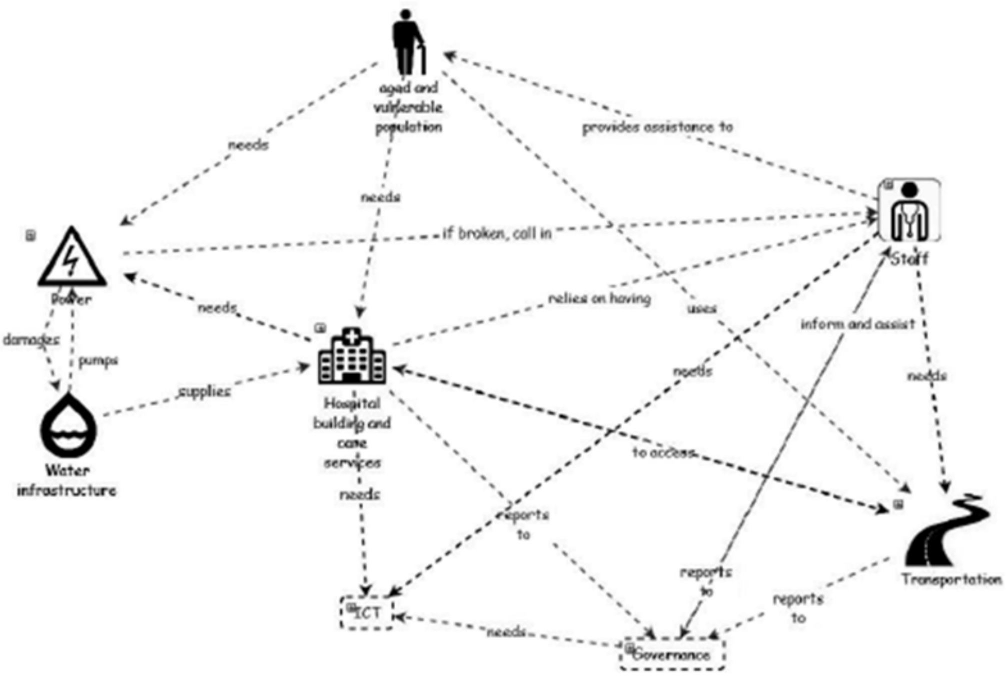

Figure 2.4: Aggregated map of linked concepts (Achour & Price, 2010).

2.3.1 Data generation

This thesis explores a new area in the field of spatial planning and water management. To gain clarity about the concepts, an explorative research is performed. The collected data will first be analysed. Then will be reflected on to what extent the information contributes to my research. The funnelling also provides some new results in the right direction by looking at the literature list. In this way is tried to gain clarity about the concepts of 'exposure', 'vulnerability' and 'self-reliance'.

To select the literature, Scholar Google and Scopus were used. These two sites are reliable for finding scientific literature on this subject. Next to this, I have experience with finding good literature on both of these two sites, but they do not show the same results. Keywords that have been used (in several combinations) are: Fragil*, Vulner*, Flood*, Hospital and Evacu*. Newspapers and news articles were used to ensure that the research is relevant (Lexus Nexus). To come up with good interview questions, eyewitness accounts were used (literature). These provide insight into the problems that other health institutions have dealt with.

The Lizard-flooding program provides the data about the possible flooding of dike ring 43. Use is made of the animation to see how a flood will develop. The water height, the velocity and how long the water remains in an area provided useful information about a possibilities and threats for the area. The model shows this information per hour. By comparing the height of infrastructure and the water height it is possible to determine until when a road is accessible if the area is flooded. The locations where the healthcare facilities are situated is very important. With the Lizard-flooding program, it is possible to determine the influence a possible flood will have on the facilities.

In the literature, an effort is made to search for eyewitness accounts of healthcare facilities concerned with a flood. These provided possible problems and solutions a facility might encounter. Compared with the situation in dike ring 43, it was possible to construct a solid interview to gain insight in the situation at hand. Interviews were conducted by interviewing an emergency coordinator and a person of the facilities department, both employed at the same institution. The results of the interviews were analysed. By comparing the various results, it became possible to draw conclusions on the overall situation of how is dealt with non-self-reliant people in dike ring 43. Moreover, conclusions were drawn upon the specific situation for these healthcare institutions.

2.3.2 Data analysis

The first sub question involves non-self-reliance and what this means for the people who reside in healthcare institutions. Another important part of the question involves the location of the healthcare institutions. To answer the first sub-question, interviews have been taken with the managers of the healthcare facilities. There is opted for three locations by which three case-studies have arisen. These are Kesteren (1), Tiel (2) and Culemborg (3) (Figure 2.5). They have been chosen due to their location within dike ring 43, namely in subareas two, three and four. Subarea one is not included because it is the most elevated area. This area is only affected when a breach occurs in the westerly part of the dike ring. Subarea five is not included because this area is the lowest and always has to deal with a deep flooding of the area. The concepts have been linked to the theory of self-reliance, exposure and vulnerability. In addition, Figure 2.4 is used. This figure clearly shows how the different concepts are connected to each other and what influence they have on one another. Both have served as inspiration for the interviews. The second sub question is about the specific policies regarding these institutions and how self-reliance is incorporated in evacuation- and security plans. The conducted interviews and the emergency plans of the healthcare institutions provide the answer to this question. The third sub question deals with the course of flooding when a dike breaks. The main interest is in how fast and up to which water level will these areas be flooded. Also there will be looked at what this means for the infrastructure and the healthcare institutions. The Lizard Flooding program provides the answer to this question.

The fourth sub question concerns how the vulnerable functions are spatially situated with respect to height, infrastructure and possible escape routes. To answer the fourth sub-question, Risicokaart.nl and GIS were used to create a map on which all healthcare institutions are to be found. In combination with the area description, their spatial situation with regard to location and infrastructure were described. The concepts of exposure, vulnerability and self-reliance were researched. What is meant exactly by exposure is important with respect to the Lizard-Flooding program and the locations the institutions are situated. Vulnerability shows how vulnerable these groups really are (if they are vulnerable as stated in the literature described above). Self-reliance shows what is understood by this concept. Use is made of literature (internet and policy documents) and information about the processes and / or locations (interviews). Where the specific vulnerable functions can be found and how these are spatially situated with respect to height, infrastructure and possible escape routes.

The fifth and final sub question covers the practical implications in the field of spatial planning and the buildings themselves. To answer these two sub-questions (three and five), a program called Lizard Flooding (by Neelen & Schuurmans) was used. Lizard-flooding is a complete web-based application that enables scenarios of flood models to be composed, viewed and managed. This is consistent with Taskforce Management Overstromingen (TMO), Veiligheid Nederland in Kaart (VNK) and the implementation of the European Floods Directive. Lizard-flooding provides insight into the course and consequences of flooding. This program shows several possible scenarios for 24 places in dike ring 43 in which the dike will possibly breach. It is possible to look at an animation which show the development of the flooding per hour, from 0 till 289 (a little over twelve days), after the flooding started. Next to this, the program shows the maximum water depth, maximum flow, the number of casualties without evacuation and the damage in the flooded area. The Province of Gelderland has granted me access to the program.

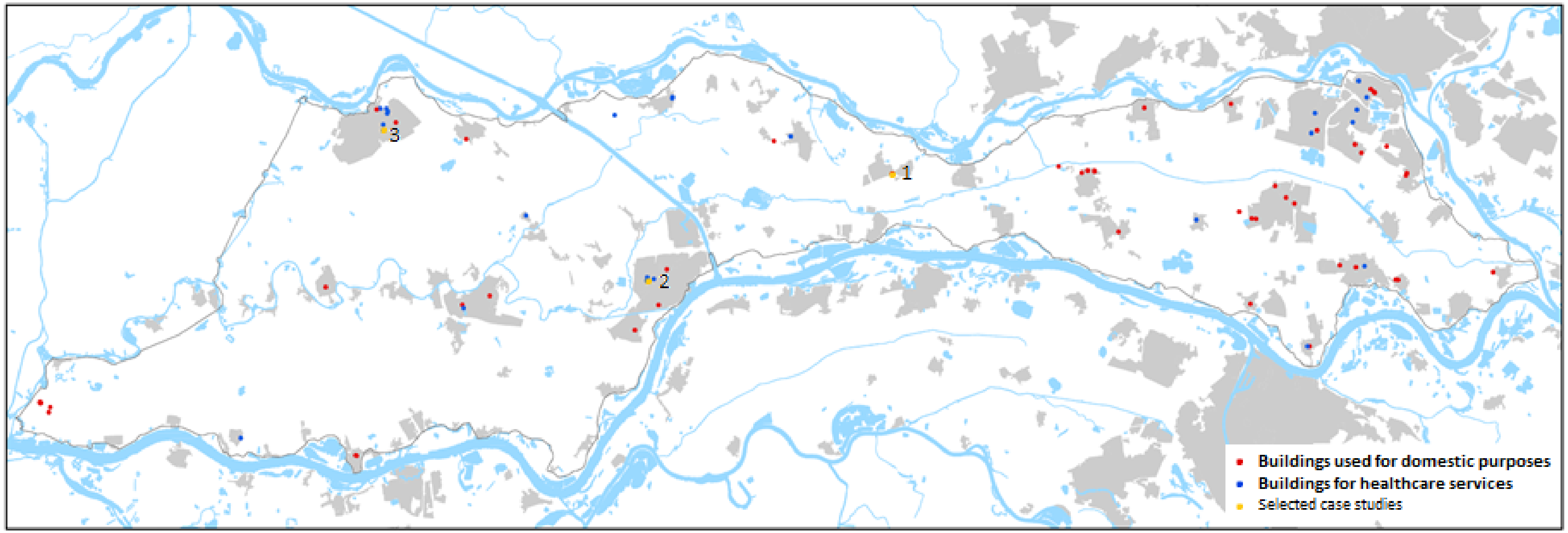

Figure 2.5: Location of the buildings of the healthcare institutions used in the case studies, Kesteren (1), Tiel (2) and Culemborg (3).

3. Research

First, an introduction into the analysis of flood scenarios is given (3.1). Since this research is a case study, there are three cases selected, namely Kesteren (Subarea 2), Tiel (Subarea 3) and Culemborg (Subarea 4). For these places is determined what effect the flood scenarios have exactly (3.1.3). The next section (3.2) discusses the interviews conducted with the institutions in these places.

3.1 Analysis of flood scenarios

3.1.1 Damage, casualties and water depth at a dike breach

The water enters our country by the Rhine at Lobith. The normative discharge, after the almost floods of 1993 and 1995, is set at 16,000 cubic meters per second (m^3 /s) (Provincie Gelderland en Min V&W, 2010). However, an increase in the normative discharge of 18,000 m^3/s in 2100 is already taken into account in current spatial plans. At *'Pannerdensche Kop'*, two-thirds of this water goes flows to the Waal, and a third flows towards the Pannerdensch kanaal. Just above *'Huissen'* is the second bifurcation point, here flows two thirds (two ninth of the total) to the Lower Rhine (Nederrijn) and a third (one-ninth of the total) to the Ijsselmeer (Provincie Gelderland, Min V&W & DHV, 2010). This is shown in figure 3.1 and table 3.1.

Figure 3.1: Discharge distribution of the River Rhine (Source: Wikipedia.org)

Table 3.1: Global distribution of discharge of the River Rhine at high tide, after division into the Waal, Pannerdensch Canal, Lower Rhine / Lek and Ijssel (Source: Provincie Gelderland, Min V&W & DHV, 2010).

River branch	Part of total at Lobith (16,000 m3/s)	Discharge (m3/s)
After the first split		
Waal	6/9	10.667
Pannerdensch Kanaal	3/9	5.333
After the second split		
Lower Rhine / Lek	2/9	3.556
Ijssel	1/9	1.778

Because the dike ring has a sloped land, a flood caused by a dike breach in the eastern part leads to a water flow from east to west. If a flood occurs in the east, it takes several days before the water reaches the westerly part. A breach in the eastern part will lead to a greater amount of water flowing into the area because the water flows away from the breach location. A dike breach in the west of the dike ring leads to flooding of the westerly part, while the eastern part will be spared. A dike breach along the Waal (southerly side) leads to a greater inflow rate than a dike breach along the Lower Rhine / Lek (northern side), because the Waal has a higher velocity (10,667 m3/s compared to 3,556 m3 per second at a discharge of 16,000 m3 per second at Lobith) (Provincie Gelderland, Min V&W & DHV, 2010).

Figure 3.2 shows that the occurring maximum water depth in the west is greater compared to the east, because the water flows from east to west and west is lower situated. This also means that the velocity of the water is higher in the eastern part of the dike ring than the westerly part. The maximum water depths in the westerly part near the Diefdijk exceed five meters. In the central area, the maximum water depths are between two and five meters. In the eastern part, the water depths are about a half up to one meter. Higher line elements such as dikes along the Amsterdam-Rhine Canal, old dikes, railroads and (high)ways remain dry or are under water with a minor depth.

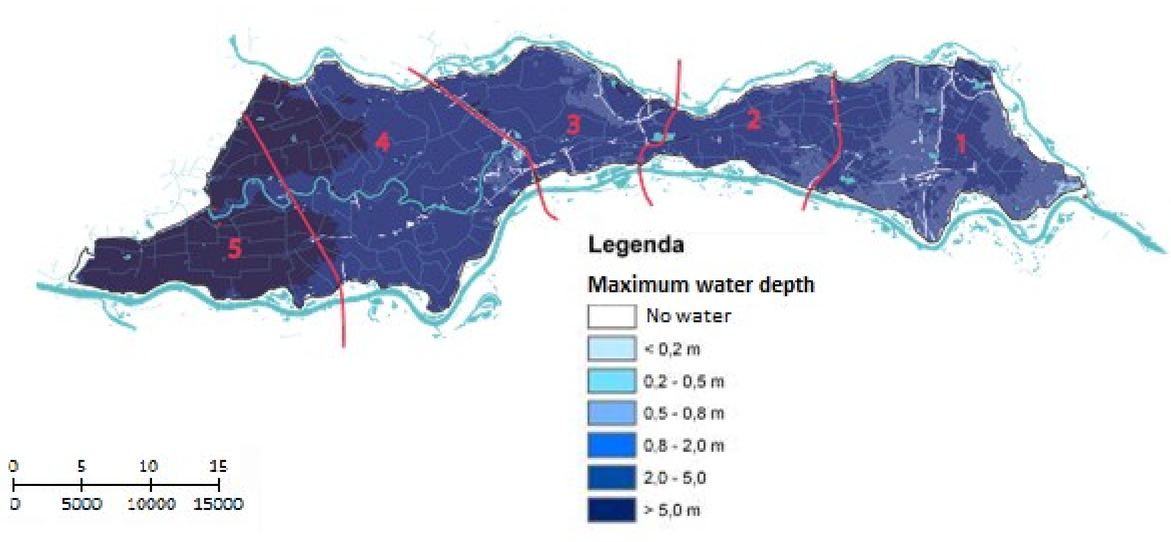

Figure 3.2: Maximum water depth at potential breakthrough locations (Source: Provincie Gelderland, Min V&W & DHV, 2010).

The hydraulic conditions and location of urban areas (high population density) provide insight into the potential damage and the number of potential victims as a result of a flood. What is striking is that the height of the potential economic damage and the number of potential victims coincides with the built-up area. The areas with the greatest potential damage are the junction Arnhem-Nijmegen (the eastern part of the dike ring area) and Tiel, Culemborg, Geldermalsen and Gorinchem East (the westerly part) (Figures 3.3 and 3.4) (Source: Provincie Gelderland, Min V&W & DHV, 2010). The population density, depth, flow velocity, risk of damage and risk of casualty can be combined to a risk profile per subarea (Table 3.2) to get an overview of the situation at hand.

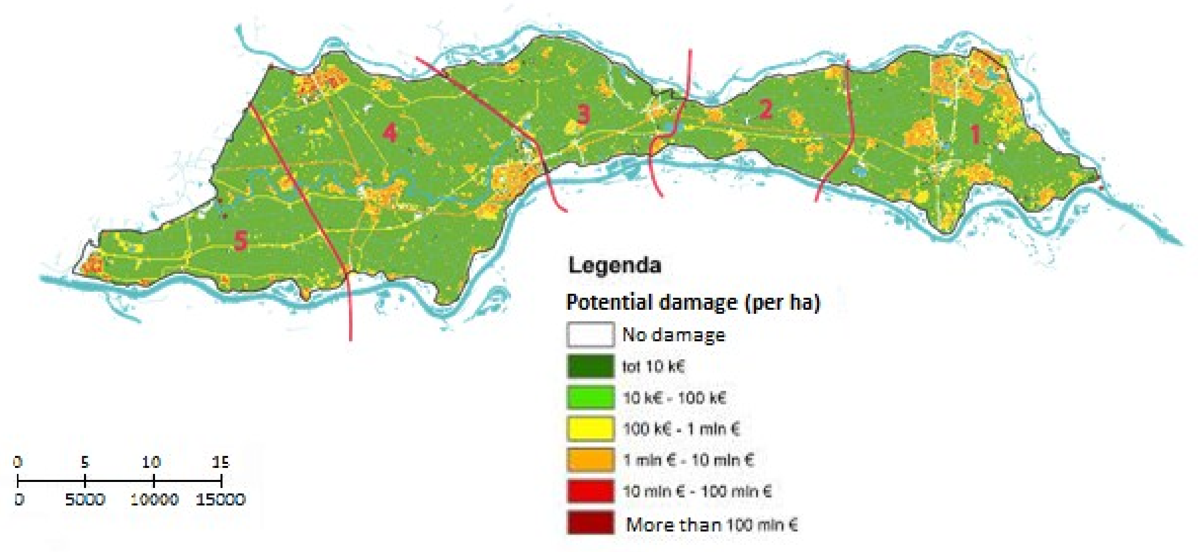

Figure 3.3: Maximum amount of damage (euro's) per hectare by flooding due to a dike breach (Source: Provincie Gelderland, Min V&W & DHV, 2010).

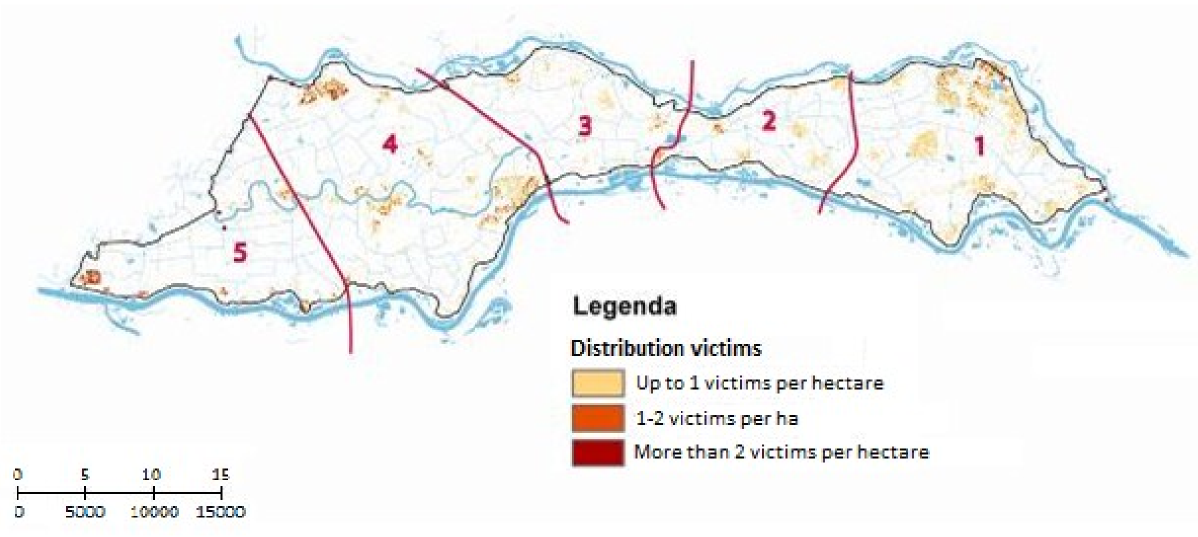

Figure 3.4: Potential number of victims per hectare by flooding due to a dike breach (Source: Provincie Gelderland, Min V&W & DHV, 2010).

Table 3.2: Risk profile per subarea, summarized in a table (Source: Provincie Gelderland, Min V&W & DHV, 2010).

	Population density	**Depth**	**Flow velocity**	**Risk of damage**	**Risk of casualty**
1	++	--	++	++	++
2	-	-	+	-	0
3	-	0	0	-	0
4	+	+	+	+	+
5	--	++	-	0	-

++ : Much; + : More than average; 0 : Average; - : Less than average; -- : Little / Small

3.1.2 Two scenarios

In this section, two flood scenarios are described. One scenario with a flood from Angeren and one scenario with a flood from Ijzendoorn. The height of the water level is measured with respect to the ground level, and not with respect to NAP. This is done to enhance the experience and because it easily forms an image, as well as the height of the site in relation to NAP is quite different among the area. As previously described, in the Netherlands we expect that we can predict a flood. In that case there will be more time to evacuate an area. The high water surge can be predicted, but with new insights into failure mechanisms such as piping, it can also be that a dike fails at another time. And this we cannot predict. These scenario's describe unexpected flash floods were the community starts to react after the disaster started.

To give an idea of what is still possible at certain water depths, an overview of critical water heights is given here. Between 0 - 20 cm of water, it is possible to protect property and possessions against damage with sand bags. At this time, cars are still able to move at walking pace. When the water reaches 20-50 cm it is still possible to reach people who need help on foot. At a water height of 50-80 cm of water, military vehicles (emergency services) are still able to drive. When the water stands between 80 cm and 2 meters, the first floor of houses is still safe. At a water depth between 2-5 meters, the second floor of houses is still safe. At a water depth of more than 5 meters, people should move towards the highest point in the house so that they are accessible for aid workers (by boat or helicopter)(Risicokaart.nl).

Dike breach near Angeren

The first flood scenario involves a dike breach in Angeren (located in subarea 1). Angeren is situated near the Pannerdensch Kanaal which connects the Lower Rhine and the Waal. Angeren is also situated near the River Rhine, the Linge and the N838. Angeren lies in the municipality of Lingewaard and has less than 3000 inhabitants. I chose this dike breach because the whole area will be affected. No one is safe from the water. The preparation time is short in the east, but the people in the lower westerly part of the dike ring have enough time to leave the area, since it will take a couple of days before the water reaches them. After a few days the water in the west is declining because it flows to the east. So this scenario provides a relatively short time for preparation and deep flooding of the east, where the nuisance lasts few days. The west has a longer preparation time, but because of its location, the area will flood deeper. The course of this flooding is described below, a summary can be found in table 3.3.

Consequences of flooding near Angeren

In the previous paragraph, the course of flooding is described using the Lizard Flooding Program. This program also allows me to look at the maximum water depth, maximum flow velocity, the number of victims without evacuation and the flood plain damage after a flood near Angeren. The parts which are flooded the deepest are clearly visible in Figure 3.5. These are the area east of the A325, the area east of the ARC, the area east of the Diefdijk and the area near the Lingebos. Figure 3.6 shows that the maximum flow velocity is highest near the breach location and between Opheusden and Kesteren. These are not the locations which are flooded the deepest, but there are a lot of victims and damage in this area (Figures 3.5 and 3.7). Densely populated areas such as Arnhem, Culemborg and Tiel will have to deal with many victims and damage as well. Near Gorinchem, the deep flooding of the area will lead to many victims and damage.

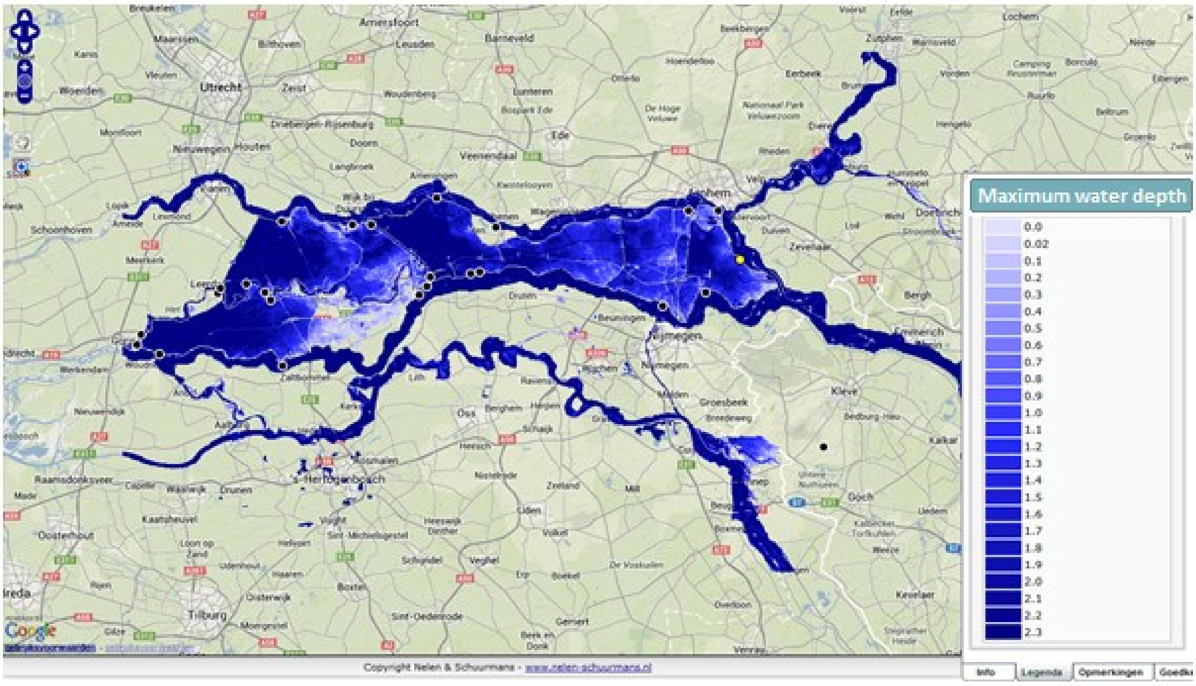

Figure 3.5: Maximum water depth after a flood near Angeren (Source: Flooding Lizard Program)

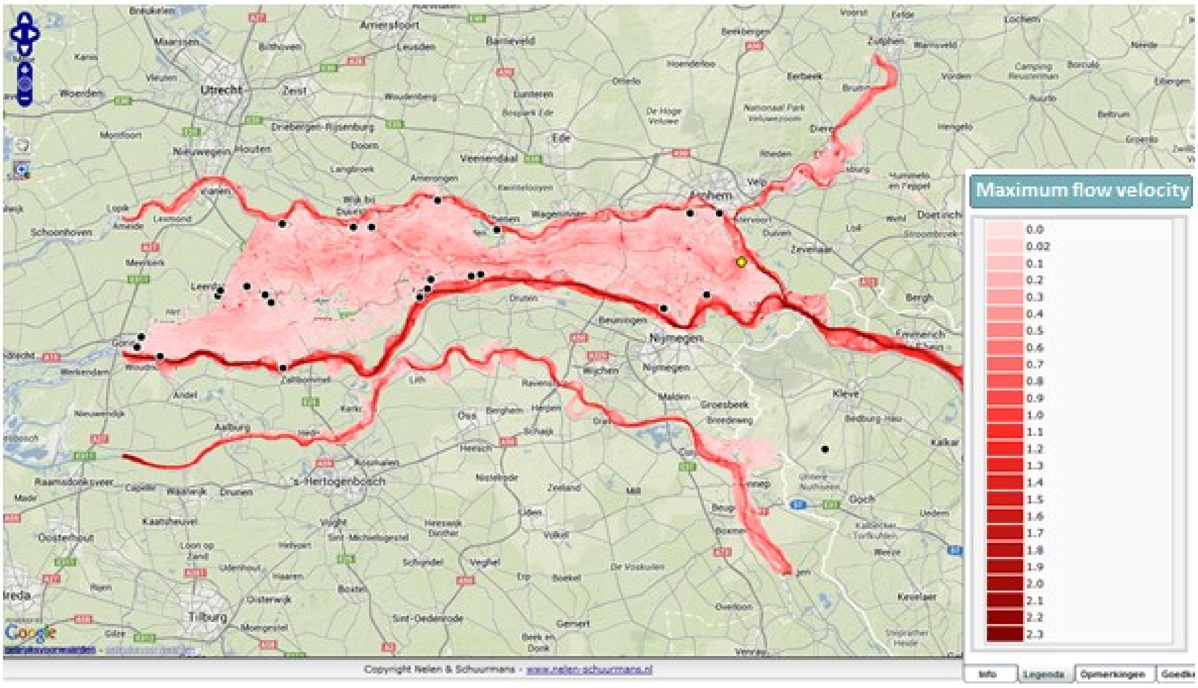

Figure 3.6: Maximum flow velocity after a flood near Angeren (Source: Flooding Lizard Program)

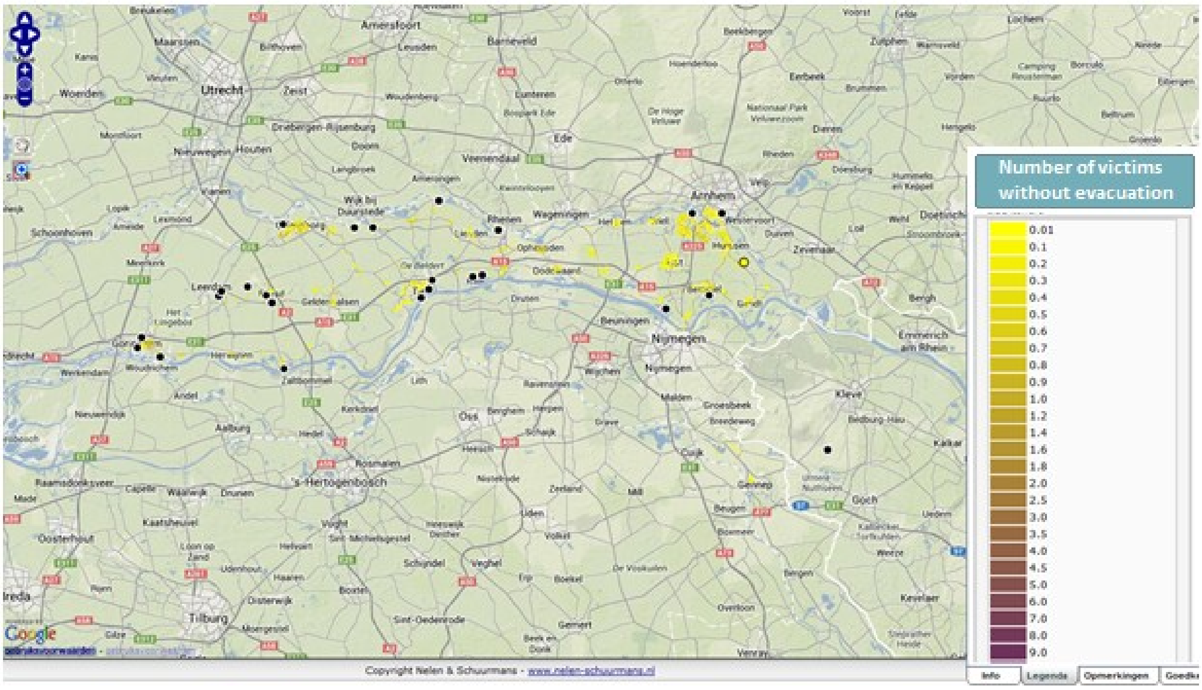

Figure 3.7: Number of victims without evacuation (1089 people) after a flood near Angeren (Source: Flooding Lizard Program)

Table 3.3: Summary of the course of flooding, dike breach in Angeren.

Location	**Time and Level of Flooding**											
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**	**Day 11**	**Day 12**
Angeren	0.4-0.8	1.0	1.0	0.6-1.0	0.6-0.9	0.6-0.8	0.2-0.8	0.2-0.8	0.0-0.4	0.0-0.4	0.0-0.4	0.0-0.2
A325	R: 7 hours (starts to flood after 18 hours)	0.0-0.8	0.0-0.8	0.0-0.6	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.4	0.0-0.4	0.0-0.4	0.0-0.4
Elst	R: 15 hours	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-0.8	0.0-0.8	0.0-0.7	0.0-0.7
A50		0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Opheusden		0.0-0.4	0.4-2.0	0.9-2.0	0.9-2.0	0.7-1.8	0.6-1.8	0.4-1.8	0.4-0.8	0.2-0.8	0.2-0.8	0.2-0.8
Kesteren			0.4-2.0	0.4-2.0	0.4-2.0	0.4-1.8	0.4-1.8	0.4-1.8	0.4-1.0	0.2-0.9	0.2-0.9	0.2-0.8
Tiel				0.0-0.7	0.0-0.8	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-0.9	0.0-0.9	0.0-0.9
Culemborg					0.0-0.7	0.0-1.8	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3
Geldermalsen					0.0-0.1	0.0-0.4	0.0-0.4	0.0-0.4	0.0-0.4	0.0-0.7	0.0-0.7	0.0-1.0
A2						0.0-0.6	0.0-1.8	0.0-1.8	0.0-1.8	0.0-1.8	0.0-1.8	0.0-1.8
Leerdam					0.0-0.2	0.0-0.4	1.0-2.3	1.6-2.3	1.7-2.3	1.6-2.3	1.6-2.3	1.6-2.3
Gorinchem						0.0-0.2	0.0-0.5	0.4-0.8	0.8-1.8	1.5-2.1	1.8-2.3	1.8-2.3

Numbers show the water depth in meters considering the entire location. Green markings show the highest water level reached. The capital R shows when the water reaches the location. (*The water level differs in the immediate vicinity of a residential area because of differences in height. The first number shows the water height at the least flooded point, the second number shows the water height at the most flooded point in the area).*

Dike breach near IJzendoorn

The second flood scenario involves a dike breach in Ijzendoorn (located in subarea 3). IJzendoorn is a village situated near the river Waal with about 1000 inhabitants, belonging to the municipality of Neder-Betuwe. I chose this dike breach because IJzendoorn is located in the middle of the dike ring next to the Waal (located in subarea 3). Because the Waal two-thirds of the water discharges from the Rhine, the flow velocity is greater than in the other rivers. As described in the theory, a greater flow velocity allows for more damage near the breach location. A larger flow rate also ensures that more m/3 water per second flows into the area and thus that the preparation time is shorter. Because the westerly part of the dike ring is located above the breakthrough location, it remains largely spared. Because this breach location is located closer to the westerly part of the dike, the preparation time for subareas three, four and five is now shorter than in the first scenario. A summary of the course of this flooding can be found in table 3.4.

Consequences of flooding near IJzendoorn

In the previous paragraph, the course of flooding is described using the Lizard Flooding Program. This program also allows me to look at the maximum water depth, maximum flow velocity, the number of victims without evacuation and the flood plain damage after a flood near Ijzendoorn. The whole westerly part of dike ring 43 will be flooded deeply (Figure 3.8). As stated before, the higher flow velocity of the Waal, results in a higher flow velocity in the area near the dike breach. This can be seen in figure 3.9, which also shows a higher flow velocity towards the ARC and the north-western part of dike ring 43. Most of the damage and the victims will occur in densely populated areas and the deeply flooded part near Gorinchem (Figure 3.10).

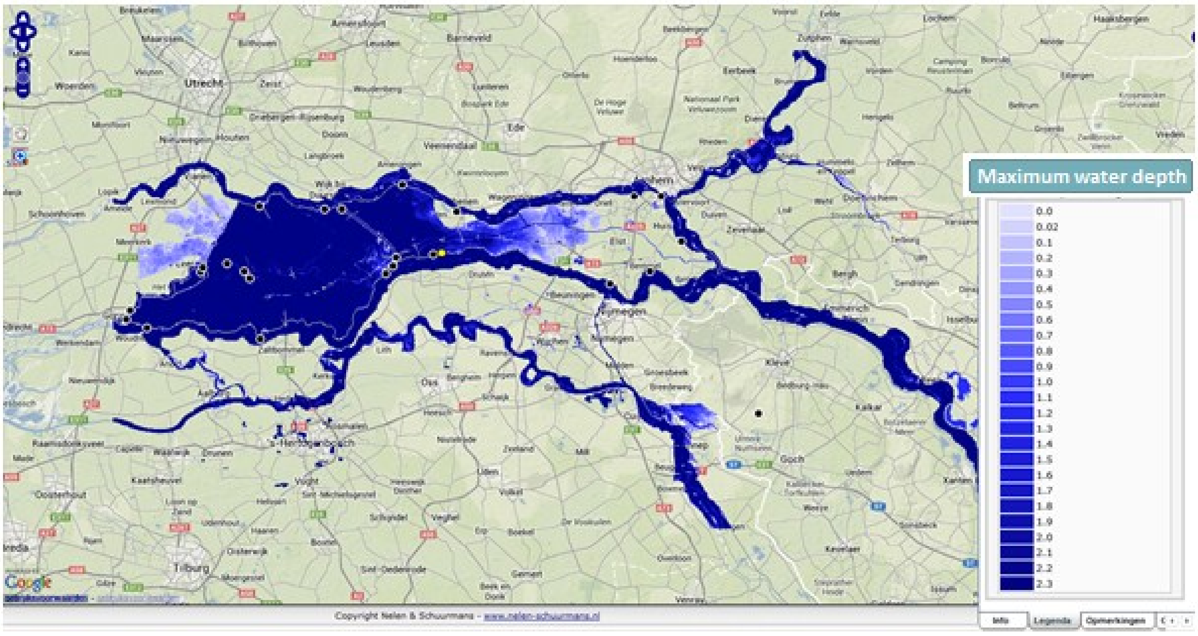

Figure 3.8: Maximum water depth after a flood near Ijzendoorn (Source: Flooding Lizard Program)

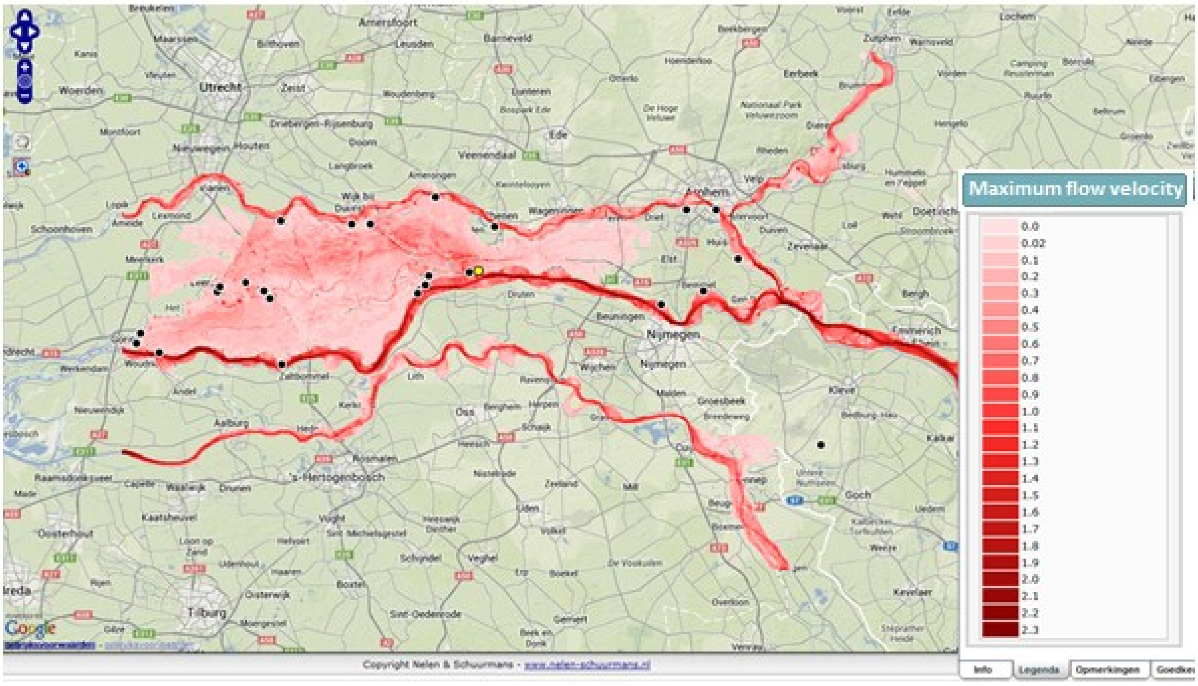

Figure 3.9: Maximum flow velocity after a flood near Ijzendoorn (Source: Flooding Lizard Program)

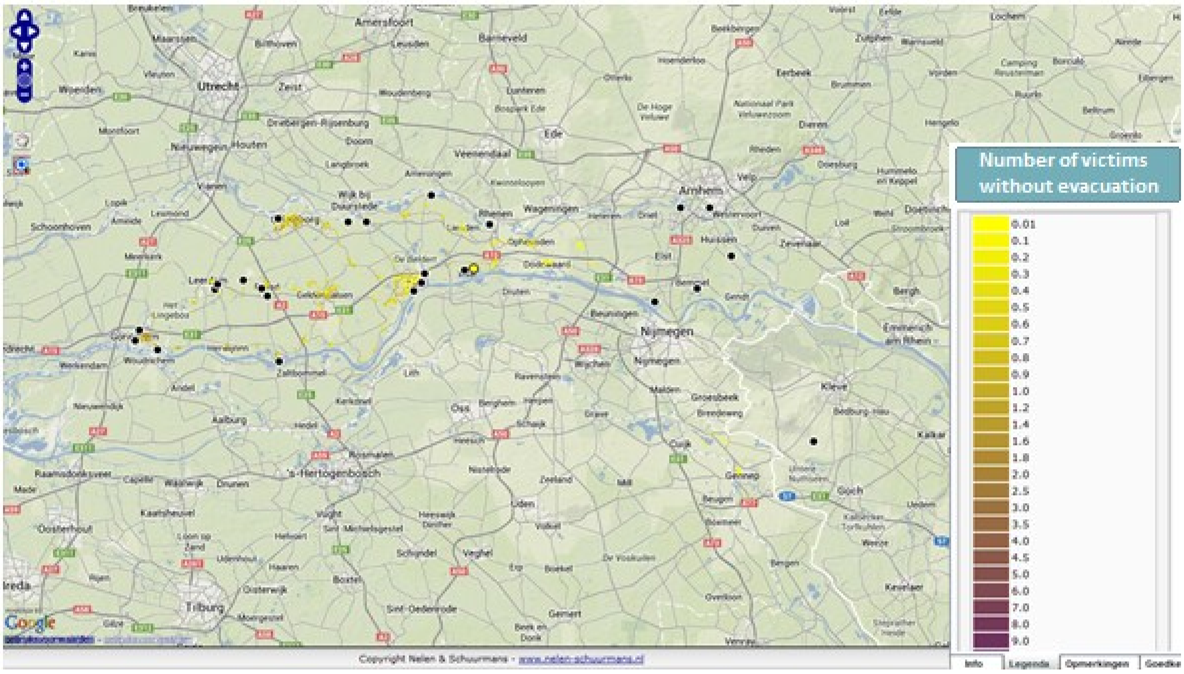

Figure 3.10: Number of victims without evacuation (1587 people) after a flood near Ijzendoorn (Source: Flooding Lizard Program)

Table 3.4: Summary of the course of flooding, dike breach in IJzendoorn.

Location	***Time and Level of Flooding***											
	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**	**Day 11**	**Day 12**
A325												
Elst												
A50			0.4									
Opheusden	0.0-0.8	0.5-1.6	0.5-1.8	0.5-1.8	0.5-1.8	0.5-1.7	0.3- 1.2	0.2- 1.1	0.2-1.0	0.2-1.0	0.2-1.0	0.2-0.9
Kesteren	0.2-1.6	0.5-1.8	0.8-1.8	0.5-1.7	0.5-1.7	0.5-1.7	0.3-1.2	0.3-1.1	0.2-1.0	0.2-1.0	0.2-1.0	0.2-1.0
Ijzendoorn	0.8-2.2	0.8-2.2	0.8-2.2	0.8-2.2	0.8-2.2	0.8-1.8	0.8-1.8	0.8-1.8	0.8-1.8	0.8-1.8	0.8-1.8	0.8-1.8
Tiel		0.0-2.0	0.0-2.0	0.0-1.9	0.0-1.9	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6	0.0-1.6
Culemborg		0.0-0.9	0.0-2.3	0.0-2.3	1.4-2.3	1.8-2.3	2.1-2.3	2.3	2.3	2.3	2.3	2.3
Geldermalsen		0.0-0.8	0.0-1.8	0.0-1.9	0.0-2.0	1.6-2.3	1.6-2.3	1.7-2.3	1.8-2.3	1.9-2.3	2.3	2.3
A2		0.0-0.4	0.0-1.4	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3	0.0-2.3
Leerdam		0.0-0.7	1.6-2.3	1.9-2.3	1.9-2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Gorinchem			0.0-0.5	1.2-2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3

Numbers show the water depth in meters considering the entire location. Green markings show the highest water level reached.(*The water level differs in the immediate vicinity of a residential area because of differences in height. The first number shows the water height at the least flooded point, the second number shows the water height at the most flooded point in the area).*

Possibilities for evacuation.

In determining vulnerability, possible evacuation routes are important. Figure 1.5 shows that in dike ring 43, Arnhem, Elst and Nijmegen (located to the west) provide high locations people can flee to (purple rings). To get out of the dike ring, people will use the roads leading towards the dikes (green arrows). These comprise the A15, A27, A50 and A2 motorway, and the local roads to get there. Near Gorinchem, there is a discharge point towards the River Waal. The more specific consequences of the possible floods in Angeren and Ijzendoorn are described per location in paragraph 3.1.3.

Table 3.5: Possibilities at different water levels.

Water level in meters	Possibilities
0 – 0,2	Cars are still able to move at walking pace.
0,2 – 0,5	It is still possible to reach people on foot.
0,5 – 0,8	Military vehicles (emergency services) are still able to drive.
0,8 – 2	The first floor of the institution is still safe.
2 – 5	The second floor of the institution is still safe.
5 <	Move towards the highest point in the house.

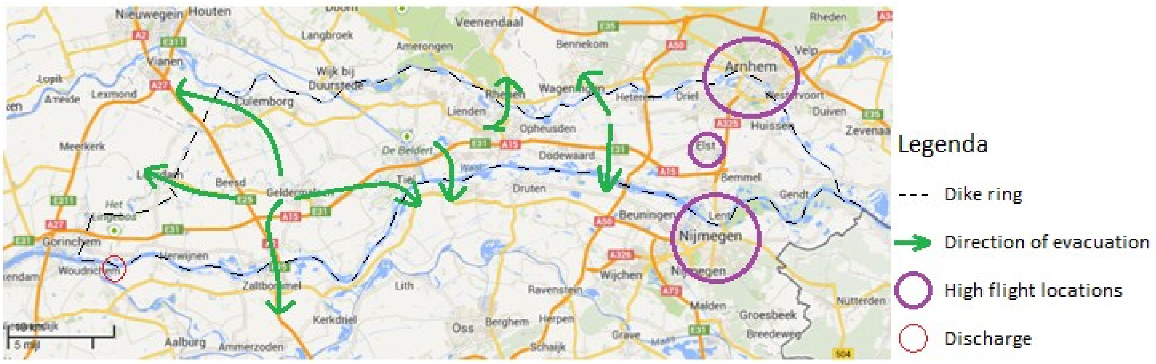

Figure 3.11: Possibilities for an evacuation derived from the interviews.

Table 3.6: Water level at different sections of the roads. (An '&' means that the water level drops, if the hours do not add up to 289, this means that the section is flooded over 80 centimetres and that people in the area can no longer be reached by road.)

Section of road	*Practicability (in meters)*	*Flooding in Angeren (in hours)*	*Flooding in Ijzendoorn (in hours)*
A325			
North of the Linge	0 – 0.20	0 – 19 & 82 – 194	n.v.t.
	0.20 – 0.50	20 – 81	n.v.t.
	0.50 – 0.80	n.v.t.	n.v.t.
Linge – A15	0-0.20	0 – 12 & 251 – 289	n.v.t.
	0.20 – 0.50	13 – 15 & 182 – 250	n.v.t.
	0.50 – 0.80	16 – 181	n.v.t.
Below A15	0 – 0.20	0 – 21	n.v.t.
	0.20 – 0.50	22 – 16 & 180 – 289	n.v.t.
	0.50 – 0.80	27 – 179	n.v.t.
A50			

North of the Linge	0 – 0.20	0 – 41 & 179 – 289	0 – 33
	0.20 – 0.50	42 – 178	34 – 56 & 211 – 289
	0.50 – 0.80	n.v.t.	57 – 110
Linge – A15	0 – 0.20	n.v.t.	0 – 46 & 225 – 289
	0.20 – 0.50	n.v.t	47 – 224
	0.50 – 0.80	n.v.t	n.v.t.
Below A15	0 – 0.20	n.v.t.	n.v.t.
	0.20 – 0.50	n.v.t.	n.v.t.
	0.50 – 0.80	n.v.t.	n.v.t.
N233	0 – 0.20	0 – 54	0 – 7
	0.20 – 0.50	55 – 59	8 – 20
	0.50 – 0.80	60 – 289	21 – 289
N323	0 – 0.20	0 – 65	0 – 4
	0.20 – 0.50	66 – 70	5 – 8
	0.50 – 0.80	71 – 87	9 – 20
N320 right of ARC	0 – 0.20	0 – 53	0 – 5
	0.20 – 0.50	54 – 62	6
	0.50 – 0.80	63 – 73	7 – 289
A2			
Diefdijk - Linge	0 – 0.20	0 – 138	0 – 48
	0.20 – 0.50	139 – 143	49
	0.50 – 0.80	144 – 158	50 – 53
Linge – A15	0 – 0.20	0 – 249	0 – 43
	0.20 – 0.50	250 – 289	44 – 65
	0.50 – 0.80	n.v.t.	66 – 99
Below A15	0 – 0.20	0 – 280	0 – 96
	0.20 – 0.50	280 – 289	97 – 103
	0.50 – 0.80	n.v.t.	104 – 120
N320 left of ARC	0 – 0.20	0 – 98	0 – 27
	0.20 – 0.50	99 – 103	28 – 30
	0.50 – 0.80	104 – 289	31 – 70
A15			
A325 – A50	0 – 0.20	0 – 40 & 172 – 289	n.v.t.
	0.20 – 0.50	41 – 171	n.v.t.
	0.50 – 0.80	n.v.t.	n.v.t.
A50 - ARC	0 – 0.20	0 – 50	0 – 5
	0.20 – 0.50	51 – 61	6 – 11
	0.50 – 0.80	62 – 289	12 – 21
ARC – A2	0 – 0.20	0 – 97	0 – 26
	0.20 – 0.50	98 – 104	27 – 28
	0.50 – 0.80	105 – 289	29 – 120
A2 - Diefdijk	0 – 0.20	0 – 147	0 – 69
	0.20 – 0.50	148 – 181	70 – 73
	0.50 – 0.80	182 – 200	74 – 81

3.1.3 Kesteren, Tiel en Culemborg

Kesteren

Flooding near Angeren

50 hours (over two days) after flooding in Angeren has started, the water reaches Kesteren. Within an hour (from 53 to 54 hours) the water reaches a height of around 40 centimetres. This means that cars can no longer be driven. After 56 hours (2 1/3 day), the water has already reached a height of 80 centimetres, emergency personnel can no longer reach the institution at this time. The southerly part of the dike ring gets flooded and the flooding spreads to the north of Kesteren. After 72 hours (3 days) the water reaches a height of 1.8 meters. Anyone who is still in the healthcare facility should be located on the second floor. After 98 hours (over 4 days), the water near the institution has reached a height of 2 meters. The southerly and westerly part of the dike ring overflow deeper, but the northern side of Kesteren remains largely spared. 104 hours (4 days) after the water has started to flood Angeren, the water near Kesteren begins to decline. This decline progresses slowly, after 147 hours (over 6 days), the water has dropped to 0.9 meters. 200 hours (8 1/3 days) after the beginning of the flood, the water near the institution has dropped to about 80 centimetres. After 220 hours (over 9 days), the institution is still flooded half a meter. The northern part is getting drier, but the deeper parts remain flooded for 50 centimetres up to 12 days after the beginning of the flood. A graphical representation is given in figure 3.12. (Classification of the flooding: slow and deep)

Flooding near Ijzendoorn

7 hours after the start of the flood near Ijzendoorn, the water reaches Kesteren. The institution is reached after 16 hours. An hour later, the water reaches a height of 40 centimetres. 24 hours (1 day) into the flood, the water reaches a height of 80 centimetres. At this point, the institution can still be reached by emergency services. The area gets more flooded, but the water height stays the same for the next two days. At 72 hours, the water starts to decline. After 100 hours, the water near the institution also begins to decline, in the north-eastern part to 40 centimetres. The area seems to be in a natural low part as the water surrounding the institution is rapidly declining and close by only begins to decline again after 156 hours. This situation remains the same the following six days. The area where the institution is situated remains flooded. A graphical representation is given in figure 3.12. (Classification of the flooding: quick and shallow).

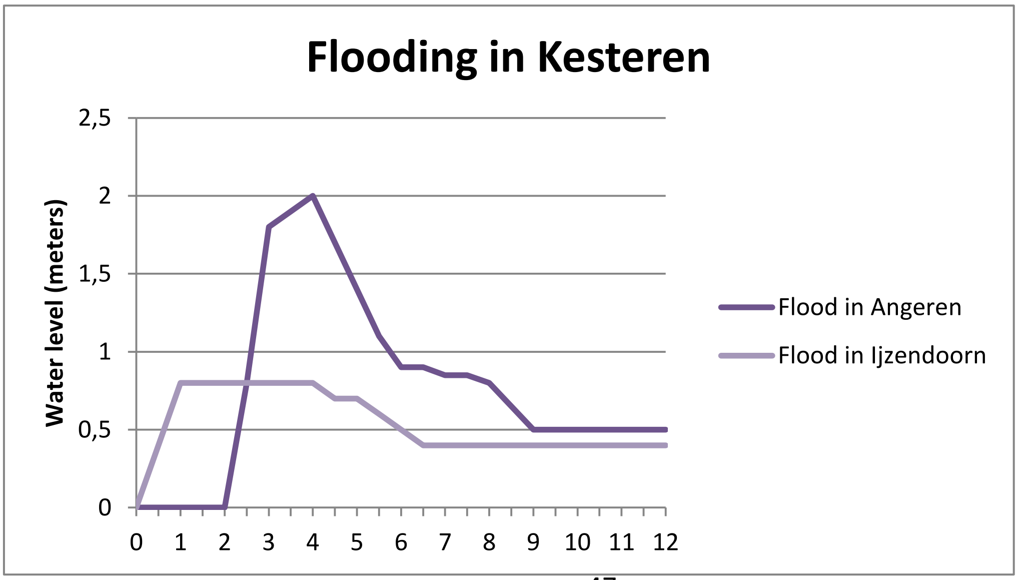

Figure 3.12: Water level in Kesteren according to the flood scenarios.

Tiel

Flooding near Angeren

The first 94 hours (almost 4 days), the flood near Angeren has no direct consequences for Tiel. These follow only when water engulfs the Amsterdam Rhine Canal and water runs into the area (after 95 hours). 105 hours into the flood, the water reaches the institution. Cars cannot drive here anymore. After 111 hours, the water has reached a level of 30 centimetres. This situation remains more or less the same over the course of the next two days. After 169 hours (7 days), the water starts to decline already. The water near the institution drops to 10 centimetres. But parts surrounding the institutions stay flooded up to about 30 centimetres. A graphical representation is given in figure 3.13. (Classification of the flooding: slow and shallow)

Flooding near Ijzendoorn

Due to the large flow of the river Waal, the westerly part of subarea three is quickly submerged. The Amsterdam Rhine Canal retains the water near Tiel. However, after 24 hours, this overflows. After 33 hours the water has reached the institution. The institution now has to deal with 30 centimetres of water, which means cars cannot drive through this area anymore. 36 Hours into the flood, the water level institution is 40 centimetres. This means that this area is only accessible by military vehicles. The area on the northern side of the river Linge floods rapidly. The water slowly penetrates a larger area of Tiel. This situation remains more or less the same over the course of the next 100 hours (about 3 days) while the water is slowly filling up the westerly part of dike ring 43. After 136 hours the water starts to rise rapidly, reaching 0.6 meters at the institution. 152 hours (6 ½ days) into the flood, the institution has to deal with 0.8 meters of water. At this point, emergency services and military vehicles can no longer drive through the area. After 176 hours, the south- westerly part of Tiel quickly starts to fill up. After 212 hours (almost nine days), the water level near the institution has reached 1.8 meters. The water level remains at the same level for the institution to 289 hours (12 days). A graphical representation is given in figure 3.13. (Classification of the flooding: quick and deep).

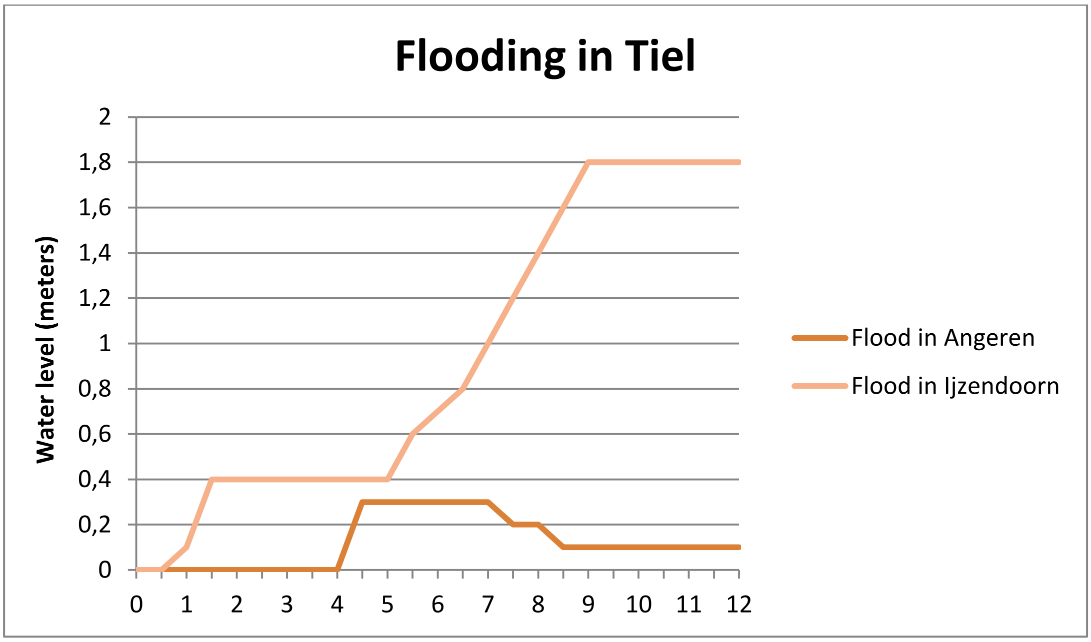

Figure 3.13: Water level in Tiel according to the flood scenarios.

Culemborg

Flooding near Angeren

The most institution in Culemborg is reached only after 117 hours (almost five days) after the flood near Angeren has started. And after 119 hours, the institution is flooded up to 30 centimetres. The flood spreads quickly and after 121 hours, the institution has to deal with a water level of 0.8 meters. The area to the left of the 'Otto van Reesweg' overflows fast, therefore the rate at which the locations come to be under water is temporary lower. However, after 172 (a little over seven days) the speed picks up again and the institution then overflows rapidly to 1.8 meters. Then the flooded part of Culemborg remains the same for one and a half day. After 208 hours the water slowly begins to decline. Especially the deep flooded section becomes smaller, but the institution remains flooded to 1.8 meters. A graphical representation is given in figure 3.14. (Classification of the flooding: slow and deep)

Flooding near Ijzendoorn

After 40 hours (1 2/3 day), the water has reached the institution in Culemborg, and it is immediately over flown by 40 centimetres of water. An hour later, the institution is affected by water levels up to 80 centimetres. 42 hours into the flood, the water level near the institution has reached 90 centimetres. Within 2 days (48 hours) after the flood has started, the institution is flooded up to 1.6 meters. After 66 hours (almost 3 days), the institution is flooded up to 1.8 meters. 74 hours into the flood, the water near the institution has risen to 2.2 meters. The situation stays more or less the same over the course of the next day. After 99 hours, the water seems to slowly start to decline, due to flooding of the western part of the dike ring, but it starts picking up again after 115 hours (almost five days). The part that is flooded up to 2.2 meters increases as time goes on. Almost the whole of Culemborg is flooded up to 2.2 meters after twelve days. A graphical representation is given in figure 3.14. (Classification of the flooding: quick and deep)

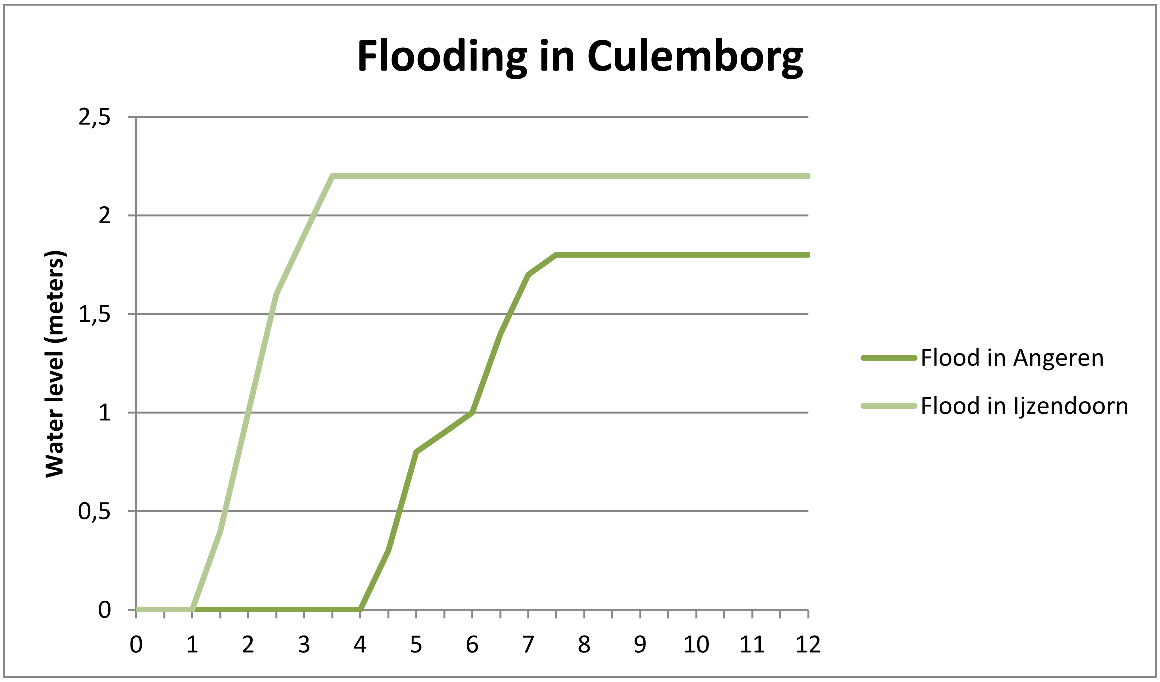

Figure 3.14: Water level in Culemborg according to the flood scenarios.

3.1.4 Conclusion

Overall, the area is inclined from east to west. This will also be the main direction of the water that comes into the area at a dike breach or an overflow of the dike. Furthermore, the area has higher parts by nature on old dikes and lower lying back lands. In case of a breakthrough of a primary flood defence, the quays along the Linge and the Amsterdam-Rhine Canal will cause a certain delay concerning the spread of the flood water. The A325, A50, Amsterdam-Rhine Canal, A2, Diefdijk and the railway form vertical elements on the map. The A15 and railway form horizontal elements on the map. To what extent these contribute to slowing down or accelerating the water and their positioning in the landscape determines whether they contribute to the self-reliance or not.

In a possible dike breach in subarea one from the Pannerdensch Kanaal, the Lower Rhine in the north or the Waal in the south, the water will flow through the area at high speed from east to west. The water depth remains generally limited to a few feet up to one meter. However, high speeds at shallow water are already dangerous for humans and animals. It can cause a lot of damage to buildings and infrastructure and hinders the transport through the area. By the combination of high population density and high velocities, the risk of a lot of damage and casualties is high in a dike breach in this area. In particular, subarea one is sensitive to a dike breach in the area itself. When a dike breach occurs in subarea two, water will only flow towards subarea one through impoundment. If a dike breach occurs in a section of a dike in subarea one, there is little time to respond because the water directly (and at high speed) flows in the area. On average, the velocities will be lower and the water depths will be higher in subarea two compared to subarea one. When a dike breach occurs from the Waal, this will cause significantly more water to flow within the area compared to a dike breach that occurs from the Lower Rhine. This is due to the velocity of the river Waal, which is greater than the velocity of the Lower Rhine. This applies to the whole dike ring area. The Amsterdam-Rhine Canal is the westerly boundary of subarea 3. In the current situation, this has an inhibitory and upward force in water coming from the subareas one, two or three. With impoundment, the water depth shall be larger, but the velocity will be lower.

Subarea four lays below the subareas two and three. This will further increase the water depth at any floodgates. When a dike breach occurs in subarea one or two, there is relatively much time to take emergency measures and thereby at least limit the casualty risk. When a dike breach occurs in the downstream subarea five 5, there is a risk that water flows into subarea four through impoundment. In that case, the flow rates are not as high, but there is relatively less time to take emergency measures. Because subarea five is the lowest point of the dike ring area, the water will always, regardless of the breakthrough location, flow towards subarea five. Furthermore, with a large influx of water, water depths in this area are increasing rapidly. This allows for water depths of more than five meters to arise.

3.2 Interviews with healthcare institutions

A part of this research consists of interviews. Three locations were chosen and people responsible for these institutions were interviewed. During the research it became clear that interviewing the MAAD could give some extra information. This information is used to get a clearer picture of the responsibilities of the institutions. So at the end of this research, they were contacted and interviewed as well.

3.2.1 Kesteren

The respondent is responsible for facility management, personnel and finance within this location. He is ultimately responsible for the aforementioned tasks. The health care institution is located in Kesteren and is specialized in people with disabilities within a Protestant or Reformed denomination. There was demand for care for these people were also religion was taken into account. They mainly take care of clients that have a more severe need of care. In total, there are 108 residents and 90 people in the daytime activities. This particular location has only one floor, they also have a swimming pool at their disposal. This institution has 350 employees of which at least 100 are needed for the daily care continuation. They rotate shifts of 8 hours. In terms of occupation, there is no difference with a situation where an evacuation takes place.

When the water supply fails, this will immediately affect the personal care of the residents. Preparing meals, washing clothes and even possible fire fighting (through a hose) are at risk. Also, there is a greater risk of legionella. Fortunately, a long period without water has not yet occurred. But in the kitchen, a supply of water and other beverage types is available, and toilets can be flushed with pumped water. With logistic stagnation in the water supply, the institution can continue to care for its clients for at least three days. But preferably not more than one day in relation to the care of incontinent clients. No other agreements have been made in the field of water supply. When the infrastructure is damaged, then especially the supply of food, goods, medicines and staff gets into trouble. For goods and medicines, a stock of about a week is available.

Figure 3.15: The healthcare institution in Kesteren.

Emergency plans

There is an emergency plan available which is also used in evacuations. For MAAD, seven items[8] must be completed and they are busy with this at the moment. Plans of the MAAD are still a part in the making. The first risk assessment is completed. Also it is arranged that in case of emergency assistance will arrive quickly.

A relocation to other buildings is possible, a prolonged stay is more difficult to realize. In 1995, the clients were brought to a colleague institution in Otterlo, it had sufficient spare capacity. Optionally, it is also possible to make use of another location or nearby institution. The evacuation in 1995 is progressed very peacefully. There was a lot of help from volunteers and external parties. Some groups of clients are more difficult to place, for example because they have behavioural problems, but the places where these people can go to are known. Behaviour groups go to a closed ward. The rest can often go to a family situation. People are evacuated by vans of the institution and possibly with the assistance of external parties. Evacuation happens over the available routes. For example, the Rhine bridge (Rijnbrug) is nearby. The driver determines the route at that time depending on the situation, he is responsible for the clients that he carries.

In all corridors, escape routes are marked and the evacuation plan is known to the staff. After evacuation it is about handling the specific incident. Evacuation is practiced annually and there is regular practice with minor incidents. Up scaling depends on the nature of the incident and where this takes place. Meeting venues are available at the institution, and for major disasters, a mobile crisis station is arranged from for example the fire department. Informing the care providers is done through a hierarchical line. The decision to evacuate rests with the responsible department, total evacuation is ordered from a higher department like the municipality. The evacuation plan is also used in flood scenarios. Emergency Response Team (ERT)[9] is in charge of an evacuation, possibly together with other care providers. Heads of departments come into view at a later stage. It takes 15-20 minutes to evacuate the institution. 12 hours are required for complete evacuation. Participants of daytime activities are left at home. Through colour stickers, the clients are classified during evacuation. This to keep track of their client's basic need for care. When the institution has been evacuated, returning can happen almost immediately after the area is declared safe, depending on the possible cleaning activities. It is however important to keep in mind that practice is less manageable than theory.

[8] 1) Shortage of staff; 2) Large supply of patients; 3) Closure of (parts of) the location; 4) Failure of equipment; 5) Logistics stagnation; 6) Outbreak of infectious diseases in an institution; 7) Moving patients (Interview respondent one)

[9] In Dutch: Bedrijfshulpverlening (BHV).

3.2.2 Tiel

The respondent is responsible for staff member facility services, everything that has to do with safety, refurbishments, renovations, Occupational Health Service (OHS)[10] and MAAD. The respondent is a project leader, both tactically and strategically. The final responsibility for facility management lies with the head of department. This institution takes care of clients with both mental and physical disorders. It specializes in care for young people with Non Congenital Brain Injury (NCBI)[11] and MS clients. This requires some planning related to the difference in schedule between younger and older. For example, the elderly go to bed at nine o'clock and the young people go out. This institution is part of a larger chain of healthcare institutions, the building itself can accommodate 114 clients. The building consists of two floors and a basement which is used for storage. The location is close to the Betuwelijn (HSL), the A15, the Waal and the ARC, it is also close to a gas station.

Emergency plans

Everything that this institution needs to function is documented in the emergency plan and care continuity plan. These are also used in the case of a flood. Escape routes are known and indicated, twice a year is practiced with a disaster. It is possible to move departments to another location, also a nearby primary school is available for emergency shelter. When many clients are concerned, the MAAD takes over. When there are problems to get staff to the location that is described in the emergency plan.

The crisis centre on site is arranged at the front desk, with a disaster of greater magnitude this can for example be located in the town hall. The ERT mainly conducts operational tasks, the management takes the lead and informs the staff members. The MAAD coordinates the evacuation of a healthcare institution and the staff belonging to the institution goes along with the clients. The near disaster in 1995 has provided the continuity care plans (before there were no plans), now at least some thought is given to the possibility of a flood. How far you continue in making plans is still a matter of debate.

In 1995, this institution is evacuated to the Province of Noord-Holland. The MAAD has an overview of each institution. How many clients they have in which category and how much reception capacity they are included herein. The decision to evacuate is dependent on many factors. In 1995, there was already some concern about the situation in the weekend, eventually they left on Wednesday and were allowed back again at the subsequent weekend. Eventually they returned partly on Monday and partly on Tuesday. This is because it takes about two days to prepare the institution for the return of the clients. The location must be heated, supplies have to be replenished, equipment and the furniture must be returned to the ground floor, computers and equipment must again be installed and put into service.

In preparation for an evacuation, the institution needs at least one day (in 1995 they had three days to prepare), evacuating the institution takes at least half a day. An acute situation will remain difficult, you cannot prepare for this and it will cause more chaos compared to a early evacuation. Re-evacuation is not documented and is less acute. One more day in a relief centre does not matter much. Continuing care and safety are more important than the location the people are in.

[10] In Dutch: Arbeidsomstandigheden (ARBO).
[11] In Dutch: Niet Aangeboren Hersenenletsel (NAH).

Figure 3.16: The healthcare institution in Tiel

3.2.3 Culemborg

The respondent is an advisor in buildings and procurement. As a safety officer he ensures that the emergency plan and evacuation plan are up-to-date. He is also co-responsible for all investment goods, contacts and everything that has to do with buildings. He clods a one-man position for all locations of this healthcare chain. This particular healthcare facility provides care to 130 clients who require psycho geriatric care, somatic care or a combination thereof. There is also room for day treatment. This location is situated in a residential area and has 17 small scale residential units with more freedom distributed over two floors. In order to function, the healthcare facility depends on electricity, water and the right people (care, kitchen, facility). Tailored care and other possibilities are offered to the customers demand if they are willing to pay extra.

Given the location of the institution, there are several roads that can be used. Problems arise only when a major disaster occurs. Food is provided by an external company, they only have too portion and heat the food themselves. External suppliers have an obligation to supply to which they must comply. The waste goes into an underground container which has a durability of at least one week. If necessary, use is made of an ambulance or a regional taxi service. There are enough supplies (food excluded) present for a week in order to continue care when the infrastructure is disrupted.

ICT is outsourced to an external organization. When the computers in this location fail, there is still access at another location, telecommuting is also possible. Patient records, care records and finances go through the computer. The institution is not completely transferred to digital yet, there are still paper patient records available. When the phone stops working, portables are used. The ERT is aware of the locations

Emergency plans

The institution has an emergency plan and evacuation plan. Flight routes are well known and displayed. The emergency plan describes how the institution can be evacuated horizontally (different location) and vertically (within the site). When evacuation is necessary, the initial reception is controlled by the institution itself, the second reception is controlled by the MAAD.

The staff regularly practices with evacuations, the residents do not participate because of associations with the war. The ERT exercises once every year (dry), once every two years with the fire department and every two years they are being sent to refresher courses. Occasionally, an alert will be undertaken to test how the staff responds.

This care institution is obliged to offer a minimum hours in quality (education / experience) and quantity (hours staffed), this is controlled by the location manager. There are also three mobile teams with ERT, these drive around to the different locations and can be on site within 10 minutes. This creates a 24-hour care assurance. Not being reachable will not happen, if it does occur, other arrangements must be made. The location manager is responsible for the people on his / her location, he / she then also takes the lead in crisis situations. There is a telephone-tree present, among themselves they keep in touch by phone. In the event of a crisis or disaster, a crisis centre is generally set up from the MAAD, where and how is determined in consultation.

The evacuation plan is also used for flood scenarios. When there is a crisis, then the (location) manager or director on site takes the lead. An announced evacuation takes about two hours to complete, when to do this is indicated by the MAAD. In the crisis plan, the procurement procedures for vertical and horizontal evacuation are described. The MAAD knows where clients must be transported to, even if they have specific conditions. There is a school nearby where we can go if the location is evacuated, other locations within the healthcare chain are also possible. The continuity of employee behaviour is unpredictable. They did go through training, but they pick up on this and use it in an emergency situation? ERT is often not the first priority for employees.

Figure 3.17: The healthcare institution in Culemborg

4. Results

This chapter deals with the results of the research. In the first section, exposure is discussed, based on the flood scenarios and theory. The second and final section is about vulnerability. The results of the interviews at the healthcare institutions and the confrontation with the theory are dealt with.

4.1 Exposure

“What is the course of flooding when the dikes break, and how quick and up to which water level will these areas be flooded, specifically looking at infrastructure and the healthcare institutions?”

The speed at which people in the healthcare institutions are exposed to water and the depth of the water after flooding determine the risk and in what areas damage will occur. The progress of both floods shows that the westerly part of dike ring 43 will be filled up by water. With the flood near Angeren, the water flows through the eastern part of the dike ring. This area only has to deal with the water for a short amount of time. The response time of the villages located in the eastern part of the dike ring is shorter, with a higher change of victims in this area. The higher velocity near the breach location will cause more damage, mainly near Angeren. Part of the A325 will be flooded within a day, up to 40 centimetres, which means no cars can use this road anymore. The A50 will flood within two days and the A2 within six days.

With the flood near Ijzendoorn, the water flows into the middle part of the dike ring. The higher flow velocity causes the area to flood very quickly. The response time of the villages located in the middle part of the dike ring is shorter, with a higher change of victims in this area. The higher velocity near the breach location will cause more damage, mainly near Ijzendoorn. Compared to the flood near Angeren, the response time for villages in subareas four and five differs in a range of days. For Tiel, the water will reach the area within two days instead of four, and for the Lingebos, the water will reach the area within three days instead of six. This difference greatly influences the preparation time of the healthcare institutions. The sooner the water arrives, the less time is available to prepare for evacuation. For the westerly part of the dike ring, the water might reach it in half the amount of time (Ijzendoorn) it would have compared to the other breach (Angeren). The A50 and A325 will remain usable for evacuation because most of the eastern part of dike ring 43 will be spared. The A2 highway however, is not usable anymore within two days, making it hard for people in the eastern part to leave the area.

4.2 Vulnerability

> *"What are the practical implications in the field of spatial planning and the buildings themselves?"*

> *"Where can you find the specific vulnerable functions and how are these spatially situated with respect to height, infrastructure and possible escape routes?"*

4.2.1 Kesteren

Evacuation

The institution in Kesteren lies close to the railroad. The most obvious evacuation routes from Kesteren are the N320 to the north (leading outside the dike ring), via the N233 to the A15 which leads to the N323 (south), A2 (west), and the A15 which leads eastward to the N325 (Figure 4.1).

Figure 4.1: Most obvious evacuation routes from Kesteren (derived from the interview).

The quickest way to leave the dike ring is by using the N233 to the north and the N323 to the south. Comparing table 3.5 to table 4.2 gives insight in the possibilities to evacuate. Figure 4.1 shows that when a flood occurs in Angeren, cars can reach the institution up to 2,2 days after the flood has started. Military vehicles can reach the institution up to 2,5 days after the flood has started and from 8,2 days onwards. From 2,5 up to 8,2 days, the first Floor is safe. Table 4.2 shows that cars can use the N233 to the north up to 2,5 days after the flood has started. Military vehicles can reach the institution up to 2,5 days and can use the N233 during the entire flood. Between 2,5 and 8,2 days, the first floor is safe. However the institution comprises only one Floor. So when the water reaches the institution, it will flood immediately without many places to go except the roof. So if people remain in the institution, they have to be saved from the roof as quickly as possible using a helicopter. The other opportunity is leaving the dike ring using the N323. Within 50 hours, there will be 20 centimetres of water on the A15 leading towards the N323, military vehicles can use this road during the entire flood. The ride-ability of this road is a prerequisite for reaching the N323 which floods a little later. It is important that in this case, the institution is evacuated within two days to be sure that everyone is safe. Table 4.1 shows that not all roads remain passible during the flood. If a flood occurs from Angeren, the N233 and the N323 are the best option since both cars and military vehicles can use it. When the flood progresses. The institution can be reached by military vehicles, but the N233 is not usable while the A15 is easier to access. The biggest problem is that this institution only consists of one layer. So it has to be evacuated within 2,5 days (Table 4.1).

Figure 4.2 shows that is a flood from Ijzendoorn would occur, cars can reach the institution up to 6 hours after the flood has started. During the entire flood, military vehicles can be used to transport people because the water does not rise above 80 centimetres. The N233 can be used by cars up to seven hours and military vehicles can use this road during the entire flood. The N323 is flooded up to 20 centimetres after only four hours, military vehicles can use this road up to 20 hours after the flood. The A15 leading towards the N323 floods a little after the A15. The A15 leading towards the A325 does not flood at all, leaving this option open for evacuation. In this case, if a flood occurs in Ijzendoorn, the first people can be evacuated by car, the rest has to be evacuated by military vehicles. Since the flooding comes from the west, evacuation using the A15 and N325 seems the best option an this remains possible over a longer period of time. Here the N233 seems the best option as well. It is the quickest route leading outside of the dike ring. It is passible for military vehicles during the entire flood (Table 4.1).

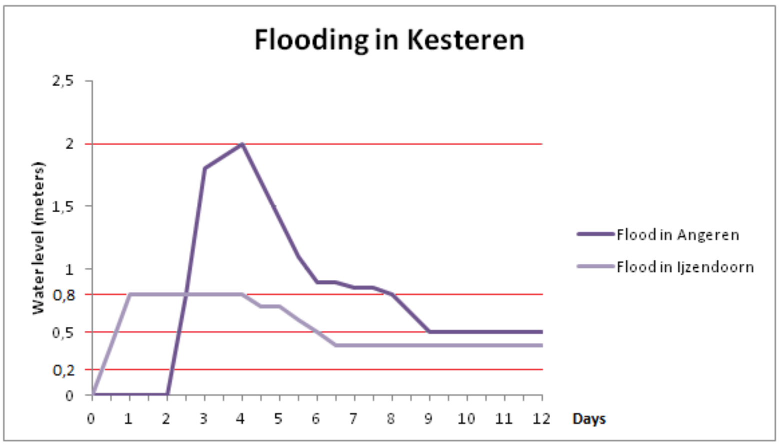

Figure 4.2: Critical water levels in Kesteren.

Table 4.1: Possibilities for evacuation in Kesteren.

Possibilities	*Number of days after the flood in Angeren has started*	*Availability of roads (derived from table 3.6)*	*Number of days after the flood in Ijzendoorn has started*	*Availability of roads (derived from table 3.6)*
Cars are still able to move at walking pace.	0,0 – 2,2	*A15: until 1,6 days* *N233: until 2,2 days* *N323: until 2,7 days*	0,0 – 0,25	*A15: until 0,2 days* *N233: until 0,3 days* *N323:until 0,2 days*
It is still possible to reach people on foot.	2,2 - 2,4 & 9,2 – 12	*A15: until 2,5 days* *N233: until 2,4 days* *N323: until 2,9 days*	0,25 – 0,6 & 6,1 – 12	*A15: until 0,4 days* *N233: until 0,8 days* *N323: until 0,3 days*
Military vehicles (emergency services) are still able to drive.	2,4 – 2,5 & 8,2 – 9,2	*A15: until 12 days* *N233: until 2,4 days* *N323: until 3,6 days*	0,6 – 6,1	*A15: until 0,8 days* *N233: until 12,0 days* *N323: until 0,8 days*
The first floor of the institution is still safe.	2,5 – 8,2			
The second floor of the institution is still safe.				

The availability of roads marked in green mean that they can contribute to the evacuation of the healthcare institution, red means that they can not contribute to the evacuation of the healthcare institution (road floods before the institution). Orange means that the road can partly contribute to the evacuation of the institution.

Institution

In order to function properly, this institution relies heavily on personnel, they are the capital of the institution. Furthermore, they are in need of telephones, logistics, housing (energy and nutrition), medicine and they have to consider infectious diseases.

When the power goes out, much equipment is being undermined and this can create problems for the institution. When computers fail, there is no access to the Electronic Patient Record (EPR)[12], there is a backup procedure using a server in another building. Thus, it is also possible to see the files from a different computer. If the main server is not available, there is a problem. It is however possible to move the main server. If the lighting falls out, the emergency lighting remains lit for at least one hour. Sliding doors can be operated manually. The air conditioning falls out, but this is no problem while maintaining continuation of care. Failure of electricity makes the work more difficult (especially at night) but without major problems.

Emergency generators come from an external company. However, when a disaster takes place, these are then seized by the government to make these available for primary assistance. Rental companies are required to cooperate with this. With new properties, it is arranged that there is one connection outside the building to provide electricity by one generator throughout the entire building at one time. An aggregate lasts for at least 12 hours. The aggregates mentioned must be

[12] In Dutch: Elektronisch Patienten Dossier (EPD).

transported, the same applies to additional diesel. So a chain reaction occurs when the power fails. Recently, there has been a fire in a transformer house outside the institution. When this happened, three generators were hired to replace it and care was provided continually.

There is no backup for the provision of clean drinking water available. For flushing toilets (and sewage) a pump is used. The reserve in drinking water and sodas from the kitchen will last for three days. When the household linen cannot be washed, there are spare clothes available for a few days. For washing the hands, alcoholic liquid is used instead of water. Showering is not possible, but in its place there is 'wash without water' available. To fight fire in this case, dry powder extinguishers are available.

The municipality is responsible for the road network, other (by)passes are possible to deliver goods and personnel to the institution. Throughout the healthcare facility, ten vans are available which are also suitable for transporting wheelchairs (8 persons). The interior of the van can be adapted to transport people horizontally as well. Medications are cooled and stored safely, food can be served cold and possibly manually. The institution has an underground waste container which lasts for at least one week, but it has more capacity. This institution is able to function normally for at least a week using the stocks, when the infrastructure becomes disrupted.

With respect to the staff, the nocturnal situation is difficult because there are fewer staff available. This is particularly difficult in an unpredictable situation. In addition, there is no support service available (day or night). When the fixed telephone fails, use is made of five portables which the ERT has at its disposal. Plus, everyone can now have access to a mobile phone. On each desk, an address/phone directory of the institution is also present. Besides telephone, it is also possible to communicate via email, people can also be reached at home. Use is also made of a phone tree in case of incidents, both from management to the staff and vice versa.

4.2.2 Tiel

Evacuation

The institution situated in Tiel is located near the hospital. The most obvious evacuation route from Tiel is the A15 in the direction of the N323 (eastward) which leads outside the dike ring. Another option is using the A15 leading towards the A2 (westward) and in the direction of the N834 and N835 which lead north towards the N320 (figure 4.3).

Figure 4.4 shows that is a flood from Angeren would occur, cars can reach the institution up to 4,4 days after the flood has started and from seven and a half days onwards. Military vehicles can reach the institution during the entire flood. The quickest way to leave the dike ring is by using the A15 to the east and the N323 to the south. Cars can make use of the N323 up to 2,5 days after the flood, military vehicles can use it up to 3,5 days. The A15 leading towards the N323 lies further away from the source of the flood, so it remains passible as long as the N323 is not flooded. The second option, using the A15 leading towards the A2, cars can make use of this road up to four days after the flood has started, military vehicles can use it during the entire flood. The A2 leads to the north, which remains passible for cars up to 5 ¾ days and for military vehicles up to almost seven days. From the A2 to the south, the road remains passible for cars up to 280 hours and the entire flood for military vehicles. Another option is making way for the N320 towards the north, but the ARC forms a barrier which restrains the water. The ARC can not be passed, therefore, this does not remain feasible.

Evacuation by car is a major challenge, but military vehicles can reach the institution during the entire flood (Table 4.2). However they can only exit the area until 3 days using the N320, 3,6 days using the N323 and until 6,5 days using the A2. Evacuation might not be the best option since the water level only reaches 50 centimetres at maximum.

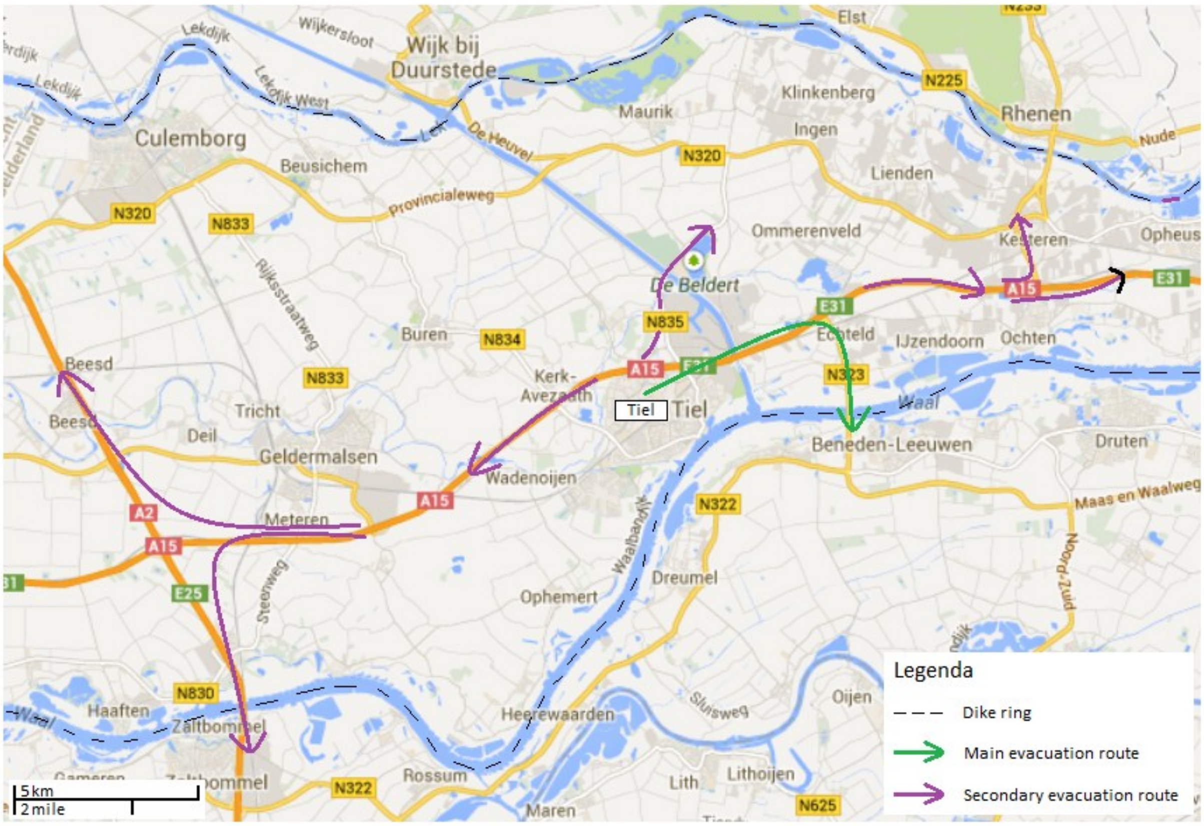

Figure 4.3: Most obvious evacuation routes from Tiel(derived from the interview).

Figure 4.4 shows that is a flood from Ijzendoorn would occur, cars can reach the institution up to 1,2 days after the flood has started. Military vehicles can reach the institution up to 6,5 days and after 6,5 days the first floor of the institution remains safe. The quickest way to leave the dike ring is by using the A15 to the east and the N323 to the south. Cars can make use of the N323 up to 4 hours after the flood, military vehicles can use it up to 20 hours. Since this time-frame is very small, it does not seem reasonable to use this road to exit the area if a flood comes from the east, if a flood comes from the west, this seems to be the best option (Table 4.2). The second option, using the A15 leading towards the A2, cars can make use of this road up to one day after the flood has started, military vehicles can use it up to four and a half days. The A2 leads towards the north, which remains passible for cars up to 1 ¾ days and for military vehicles up to two days. From the A2 to the south, the road remains passible for cars up to four days and up to five days flood for military vehicles.

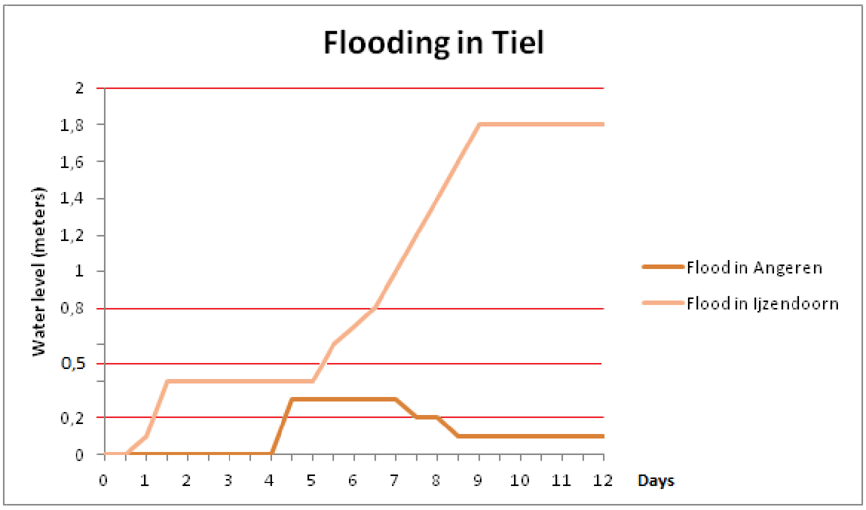

Figure 4.4: Critical water levels in Tiel.

Table 4.2: Possibilities for evacuation in Tiel.

Possibilities	*Number of days after the flood in Angeren has started*	*Availability of roads (derived from table 3.6)*	*Number of days after the flood in Ijzendoorn has started*	*Availability of roads (derived from table 3.6)*
Cars are still able to move at walking pace.	0,0 – 4,4 & 7,5 - 12	*A15 east: until 2,0 days* *N323: until 2,7 days* *A15 west: until 4,0 days* *A2: until 5,7 days* *N320: until 2,2 days*	0,0 – 1,2	*A15 east: until 0,2 days* *N323: until 0,2 days* *A15 west: until 1,0 days* *A2: until 1,7 days* *N320: until 0,2 days*
It is still possible to reach people on foot.	4,4 – 7,5	*A15 east: until 2,5 days* *N323: until 2,9 days* *A15 west: until 4,3 days* *A2: until 5,9 days* *N320: until 2,5 days*	1,2 – 5,3	*A15 east: until 0,4 days* *N323: until 0,3 days* *A15 west: until 1,1 days* *A2: until 2,0 days* *N320: until 0,25 days*
Military vehicles (emergency services) are still able to drive.		*A15 east: until 12,0 days* *N323: until 3,6 days* *A15 west: until 12,0 days* *A2: until 6,5 days* *N320: until 3,0 days*	5,3 – 6,5	*A15 east: until 0,8 days* *N323: until 0,8 days* *A15 west: until 5,0 days* *A2: until 2,2 days* *N320: until 12,0 days*
The first floor of the institution is still safe.			6,5 - 12	
The second floor of the institution is still safe.				

The availability of roads marked in green mean that they can contribute to the evacuation of the healthcare institution, red means that they can not contribute to the evacuation of the healthcare institution (road floods before the institution). Orange means that the road can partly contribute to the evacuation of the institution.

Institution

Utility companies are responsible for the supply of electricity and water. This institution has access to an emergency generator on the ground floor. It runs for 48 hours, on the other locations, small mobile aggregates are present, for example to move beds. If there is no power, the elevators are operated by a battery that lasts for about half a day. Without power, the air conditioning fails as well. However, this poses no problems for the continuation of care. The lights go out and the emergency lights go on. Among people who are dependent on oxygen, a separate generator or concentrator can be used. If necessary it is possible to connect these to the emergency power. There are aggregates and oxygen cylinders at hand, so the first 24 hours will therefore pose few problems in continuing care.

A few days before the interview, the water supply failed for a couple of hours. To overcome this there are packages with water located in the basement. Per person, both clients and staff, one litre of water is available. When the water supply is lost, this institution can continue providing care for another day. This institution prepares the food for the clients themselves. Without water it is more difficult to cook. There are alternatives such as porridge and beans in an emergency situation. If this happens and the situation lasts longer, then you start to improvise anyway. Such as retrieving water from the canal to flush the toilets. Washing linen happens externally. The washing of the hands is done with alcohol. In addition, use can be made of "washing without water." This is also used when diseases are prevalent. In this institution, no sprinkler system is present, putting out a fire is done by using fire hoses and CO_2 extinguishers.

The food for the clients is delivered daily by truck, the medication is supplied by a nearby pharmacy. The supply of medicines is sufficient to last a week. The healthcare chain has access to eight vans of their own vans which can accommodate up to eight clients each. The institution has an underground container where waste can be stored during 7-14 days.

The servers of the ICT stand at an external company in Amsterdam. On these servers, the data of the clients (EPD) is stored. There is also a back up of this data available. Also, the data of clients can be found in hard-copy files that are stored in the basement. When there is an evacuation, the head of department is responsible for taking these along. These documents are kept up-to-date as well as possible. The computer mainframe is cooled with cooling liquid and not with water. It only experiences hindrance when the electricity fails, however, then the computers themselves drop out so cooling is no longer needed.

People inform each other in the first instance by calling. Names and numbers of executives are known within the various departments. When the telephone fails, communication is possible through portables, 15 of these are available in all locations combined. Cars can also be driven in between locations to stay informed.

4.2.3 Culemborg

Evacuation

In Culemborg, the institution is situated in the eastern part of the village (figure 4.5). The most obvious evacuation routes from Culemborg are the N320 leading westwards towards the A2 and from there onwards to the north and to the south. Another way to evacuate is using the N320 eastwards towards the N233, or towards the east of west using the A15.

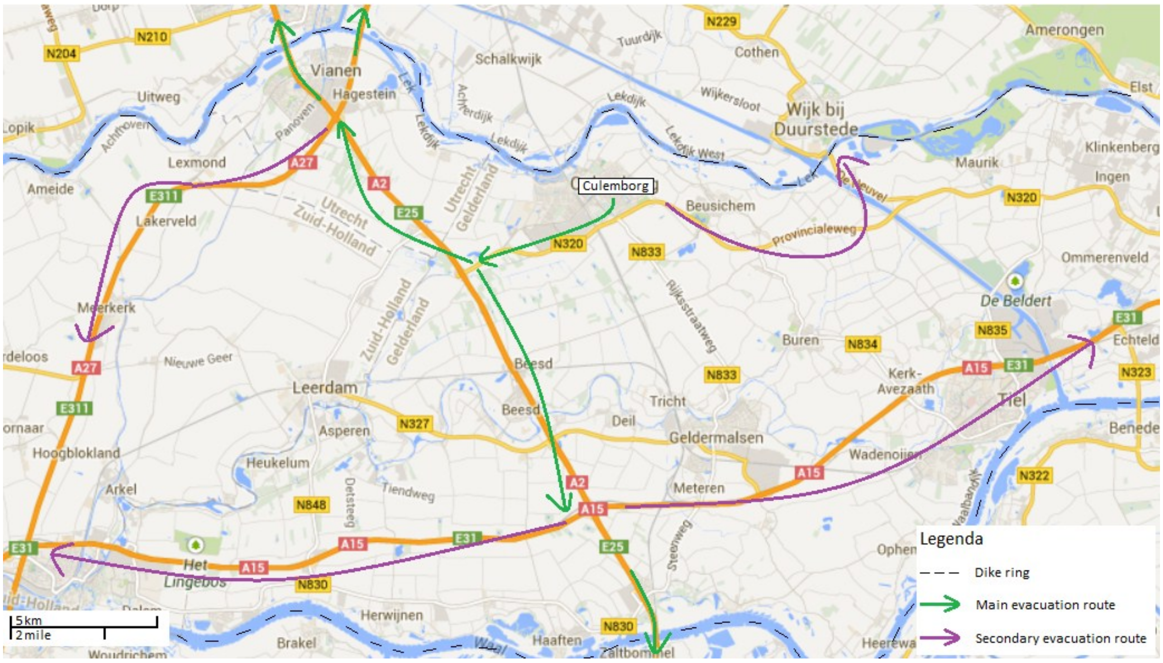

Figure 4.5: Most obvious evacuation routes from Culemborg.

Figure 4.6 shows that is a flood from Angeren would occur, cars can reach the institution up to 4,4 days after the flood has started. Military vehicles can reach the institution up to five days after the flood has started. From five up to twelve days, the first Floor is safe. The quickest way to leave the dike ring is by using the N320 leading towards the west and the A2 to the north. The N320 can be used by cars up to four days after the flood has started, military vehicles can use it during the entire flood. The A2 towards the north can be used by cars up to 5 ¾ days, military vehicles can use it up to six and a half days. Towards the south, the A2 remains passible for cars up to ten days after the flood has started, military vehicles can make use of it during the entire flood. The third option is using the N320 eastwards, to the N233. However, the N233 floods before the water reaches Culemborg, so it is not feasible to use this route for evacuation. Last, the N320 to the west and A2 to the south can be used to reach the A15 which leads to the east or to the south. Both floods come from the east, so the easterly part of the A15 will be flooded before the westerly part does. When the A2 gets flooded, the A15 leading towards the west can not be used for an evacuation. The westerly part remains passible up to six days for cars and up to 8 ¼ days for military vehicles. As long as the institution can be reached by military vehicles, they can exit the area using the A2 (Table 4.3).

Figure 4.6 shows that is a flood from Ijzendoorn would occur, cars can reach the institution up to 1,3 days after the flood has started. Military vehicles can reach the institution up to 1,9 days after the flood has started. From 1,9 up to 3,2 days, the first Floor is safe. During the rest of the flood, only the second Floor remains safe. The quickest way to leave the dike ring is by using the N320 leading towards the west and the A2 to the north. The N320 can be used by cars up to one day after the flood has started, military vehicles can use it up to three days. The A2 towards the north can be used by cars up to two days, military vehicles can use it up to 2 ¼ days. Towards the south, the A2 remains passible for cars up to 1 ¾ days after the flood has started, military vehicles can make use of it up to four days. The westerly part remains passible up to 2 ¾ days for cars and up to 3 1/3 days for military vehicles. As long as the institution can be reached by military vehicles, they can exit the area using the A2 (Table 4.3).

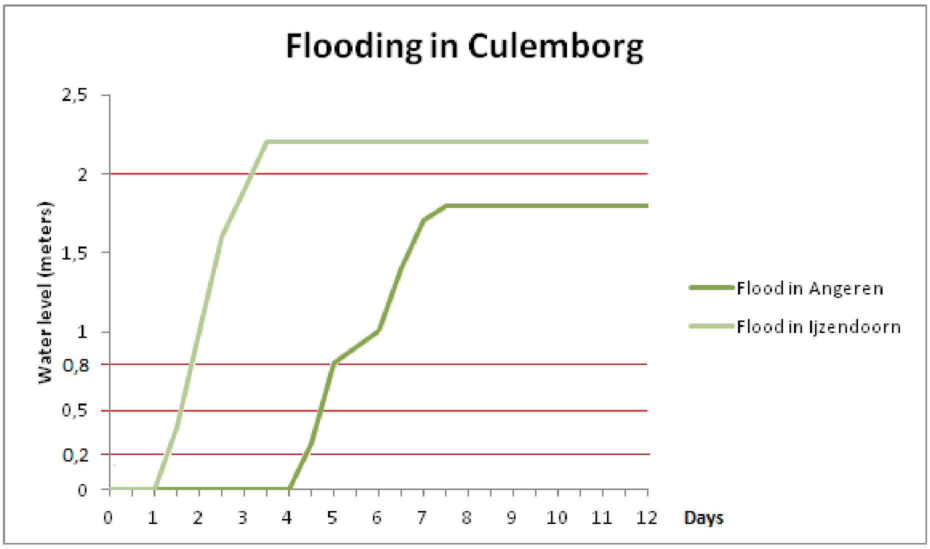

Figure 4.6: Critical water levels in Culemborg.

Table 4.3: Possibilities for evacuation in Culemborg.

Possibilities	***Number of days after the flood in Angeren has started***	***Availability of roads (derived from table 3.6)***	***Number of days after the flood in Ijzendoorn has started***	***Availability of roads (derived from table 3.6)***
Cars are still able to move at walking pace.	0,0 – 4,4	*N320 east: until 2,2 days* *N320 west: until 4,0 days* *A2 north: until 5,7 days* *A2 south: until 5,7 days*	0,0 – 1,3	*N320 east: until 0,2 days* *N320 west: until 1,1 days* *A2 north: until 2,0 days* *A2 south: until 1,7 days*
It is still possible to reach people on foot.	4,4 – 4,7	*N320 east: until 2,5 days* *N320 west: until 4,2 days* *A2 north: until 5,9 days* *A2 south: until 5,9 days*	1,3 – 1,6	*N320 east: until 0,2 days* *N320 west: until 1,2 days* *A2 north: until 2,0 days* *A2 south: until 2,0 days*
Military vehicles (emergency services) are still able to drive.	4,7 – 5,0	*N320 east: until 3,0 days* *N320 west: until 12 days* *A2 north: until 6,5 days* *A2 south: until 6,5 days*	1,6 – 1,9	*N320 east: until 12 days* *N320 west: until 2,9 days* *A2 north: until 2,2 days* *A2 south: until 2,2 days*
The first floor of the institution is still safe.	5,0 - 12		1,9 – 3,2	
The second floor of the institution is still safe.			3,2 - 12	

The availability of roads marked in green mean that they can contribute to the evacuation of the healthcare institution, red means that they can not contribute to the evacuation of the healthcare institution (road floods before the institution). Orange means that the road can partly contribute to the evacuation of the institution.

Institution

It is difficult to work without power. There are bedridden clients who then have problems (they depend on a special mattress) and making oxygen for clients is difficult as well. These clients are at larger locations and are connected to emergency power. This location is equipped with a diesel generator, which lasts for 24 hours. There is no stock of Diesel because it can spoil. The aggregates are tested monthly. The telephone, lighting and specific sockets with a red border are equipped with emergency power. When the power fails, the care can be continued, if necessary there is a space with emergency power which can be used for clients who need it.

If the electricity fails, the corridor lighting continues to work and emergency lights work for two hours only (battery). The elevators are suitable for beds and wheelchairs. When the elevators and sliding doors no longer work, assistance of the fire department is needed. The air conditioning fails as well. This is unfortunate, but it runs mainly for the staff. Clients get cold very quickly because they sit still most of the time. The utilities are responsible for electricity and water. When the boiler of the institution is empty, there is no water available. Then bottles or jerry cans have to be provided. The institution has been without water for a few hours, this caused no problems. What to do when the toilets cannot be flushed anymore, has to be determined at that time. The washing of linen is for the most part done by an external company. For washing hands, alcohol gel is used. For showering, use is made of cloths without soap. Potable water for consumption comes from bottles. For cleaning of the institution, microfiber cloths (without water) are used. A sprinkler system is not present, this also applies to a computer mainframe.

In 1995 the evacuation went sometimes good and sometimes chaotic (back then, the institutions were not yet merged). Buses were coordinated from the municipality, one had to wait long on these. Everything else they had to arrange themselves. Elderly people could use field beds (the military), this was often a problem because it took a long time.

4.2.4 MAAD

The MAAD started in 2005/2006. They contacted all healthcare organizations to get the bigger picture. Important tasks are promoting awareness (obligation to continue to care for at least 72 hours, even in difficult situations), planning process (making plans, organizing platform) and cooperation (between PHS[13] and MAAD as with other cooperating organizations). Parties cooperating deliver the key figures (fire department, police, health services). The officer on duty from each of these parties determines what for his service should be done in case of a disaster.

Healthcare institutions have to deal with the MAAD in two different situations: In preparation for accidents and disasters (care continuity and plans for this) and 2) in an (imminent) accident or disaster (support). MAAD is responsible for the network: emergency medical care (acute), preventive health care and psychosocial aftercare (public, conducted by the Public Health Service).

Institutions themselves are responsible for providing accurate information and keeping this information up-to-date in GHOR4ALL. GHOR4ALL is a system in which all known health care institutions including information are displayed (how many patients, how many in wheelchairs, special needs, transportation availability and mutual arrangements). The seven consequences

[13] Public Health Service (PHS); In Dutch: Gemeenschappelijke Gezondheidsdienst (GGD)

introduced earlier stand for the continuation of their own care processes and contribute to awareness. This system makes it easy to search by computer to find information about for example which available, arrangements made by the institution or how many institutions are located in area. MAAD thus has access to the information about the vulnerable people in the institution and their contact information. In a disaster, the MAAD calls the affected institutions every three hours to check on how it goes and whether additional measures should be taken. They try to make the best arrangements possible. You can not take care of the entire 100% of the risk, a residual risk remains. We often deviate from plans. But these plans do provide structure and adjustment is not a problem.

Different institutions have different solutions. Not every solution works equally well for every institution. The MAAD also established a platform. Through the platform, institutions can talk to each other, gain ideas and learn from each other. Not all institutions have their own generators through for example cutbacks and maintenance costs. Institutions must make their own arrangements with companies for at least the first 72 hours. If necessary, the MAAD can give priority in arranging aggregates in a crisis. When there is a need for beds to accommodate, for example, evacuees, they will not be supplied by the MAAD. But they do maintain contacts with local authorities and the Red Cross who have beds at their disposal. MAAD uses its network of contacts in for example arranging ambulances when evacuating bedridden patients.

5. Conclusion, Discussion & Recommendations

5.1 Conclusion

The environment is classified in the physical environment, with built structures like healthcare institutions, and the social environment with individuals in the institutions or people ruling it. Both are important in spatial planning. The built structures of healthcare institutions are considered vulnerable objects. If something happens to them, like a flood, they have many potential victims. These vulnerable objects rely on vital networks for several services. The vital networks cause damage in a society if their services are lost.

"What is vulnerability in the case of a flood and to what extent this is already taken into account in the context of evacuations of non-self-reliant people in healthcare institutions?"

5.1.1 Vulnerable objects (Kesteren, Tiel, Culemborg)

For all the institutions applies that when they are no longer accessible for certain vehicles, the availability of roads adds nothing to the potential for evacuation. Especially since these clients need help in leaving the area. A flood near Angeren seems to have less drastic effects on the environment compared to the flood in Ijzendoorn. People in the westerly part of the dike ring have to be evacuated in both floods because the area is flooded so deeply. In case of the flood near Ijzendoorn, they will not have enough time to evacuate. This problem will increase if surrounding dike rings are threatened as well.

Crisis management and Emergency planning

The safety region brings together several administrations and services with respect to tasks in the field of fire fighting, disaster management, crisis management, MAAD and maintaining public order and security. Emergency plans often focus on emergencies outside the healthcare institution, but through this research has become clear that the institutions are prepared for any kind of disaster. They have plans in which their arrangements for a shortage of staff; large supply of patients; closure of (parts of) the location; failure of equipment; logistics stagnation; an outbreak of infectious diseases in an institution; and moving the patients are described. All of these are necessary to continue care. And by taking care of this they can battle any problem. If problems arise, the MAAD can assist them through its contacts and 'umbrella' function in healthcare. All institutions showed that they are capable of taking care of themselves for at least 72 hours. The plans are tailored to the healthcare institutions. And they do deviate from plans. But from the interview with the MAAD appears that these plans do provide structure and adjustment is not a problem. It provides flexibility in case of a crisis. Also, all the institutions have an ERT which practices at least once a year. It is not possible to cover every risk and every 'if'.

Evacuation

Preparing for an evacuation takes time. This is certainly the case in a healthcare facility where people are less able to do things themselves. Also, special arrangements have to be made. The institutions have done this, and if a large-scale crisis would occur, they can contact the MAAD. If all the people in an area finally sit in the car, they are caught in a traffic jam. When the dike breaks, it is really a problem. The institutions are aware of this and are a little afraid of this to happen as well. I becomes harder to evacuate an area if escape routes get congested. If this happens, the MAAD can contact the police and make arrangements for less stable patients if necessary. It is advisable to classify clients, for example by using coloured straps, as is done in Culemborg, to be able to track clients and because it helps with the continuation of care. All institutions showed that they need at least twelve hours to get ready for an evacuation. In an acute situation this is not always possible and they will need help when this happens. We can make many plans, but the limiting factor is the human being.

The institution in Kesteren has to be evacuated within 2,5 days if a flood occurs in Angeren. The institution does not have a second floor and after 2,5 days the water will have risen to 80 centimetres. So actually it needs to be evacuated before the water reaches the institution. The patients there have nowhere else to go. This also counts for a flood occurring from Ijzendoorn. The absence of a second floor makes it impossible to let people stay in the institution during the flooding. A flood will give a lot of trouble, no matter the preparation.

When the institution in Tiel is hit by a flood from Angeren, the water level does not exceed 50 centimetres, leaving the people inside the institution is an option here. Certainly since the roads by which these people need to be evacuated will be flooded. Because the roads are interconnected with each other, there is dependence. If a flood occurs from Ijzendoorn, it is possible to reach the institution up to 6,5 days with military vehicles. This is due to the westerly part of the dike ring filling up with water, giving the institution extra time to evacuate. But the escape route to the east is only passable up to 0.8 days after the onset of the flood, for the west this is 2.2 days. As a result the time slot in which the evacuation should take place becomes a lot smaller.

For the institution in Culemborg applies that when a flood takes place from Angeren, within five days is no longer accessible for military vehicles. When a flood takes place from Ijzendoorn this is only 1.9 days. However, the roads remain passable for military vehicles. Evacuation options are dependent on the accessibility of the location of the institution.

The biggest problems would arise if problems occurred at night since less staff is present at that particular time. The institution in Culemborg has a mobile team which can assist if something like this happens. This could be an idea for the other institutions as well. The back-up systems are available or arranged at every institution interviewed.

5.1.2 Vital networks

The functioning of critical infrastructure is crucial for the functioning of an area, because (temporary) failure can cause social disruption (victims / economic damage / self-reliance). Loss of vital infrastructure in flooded areas can lead to failure in non-flooded areas and thus to a spread of the effects of the flooding. The indirect damage of failure of critical infrastructure can be quite large (many times larger than the indirect damage). Critical infrastructure is also needed for emergency response. The vulnerability of critical infrastructure should be properly included in the emergency plans. In order to function properly, all healthcare institutions rely heavily on electricity, water, personnel, telephones, computers, logistics and all networks used by these.

5.2 Discussion and Recommendations

Different regions for responsible organizations

The zoning presents difficulties. An institution in Geldermalsen belongs to this security region in Nijmegen, but perhaps is related to Den Bosch because it is closer by. The police region is not the same as the security region. This makes tasks and responsibilities more difficult, especially when cooperation within a region is required. For example, in two adjacent areas, the same police region can be responsible, but another safety region. This problem is exacerbated by the introduction of the national police. Where the safety regions tried to line up with the police regions, the situation will be different in the future. Another problem is that the MAAD concerns the regional governance, the police is now a national body (rather than regional one). This can pose problems and ambiguities while the various plans should connect to each other.

Home care

Awareness of self-reliance of people who receive home care can be arranged through a patient association. The organization could remind people that they should take facilities or arrangements. For example to indicate their neighbours that they are not able to move themselves or that they can not hear the sirens in case of emergency. Where all these people live is not yet known. There is contact with most of the home care organisations (who take care of these people), but there are some complications like the earlier described zoning. Sometimes they are not sure what they have to do with the MAAD. Home care organisations are not responsible for issues like electricity at the homes of their clients, on the other hand they have to ensure that they can continue care.

The MAAD has initially focused on institutions with more than 15 clients and / or institutions with clients with high care needs. This because of their vulnerability and to maintain overview. In general, people in home care receive help in housekeeping, but they live independently. But as awareness increases, smaller organisations start to contact the MAAD as well. Questions can be raised about whether this should be mapped and how soon. Also, for instance, arrangements for schools and childcare could be included, should a disaster occur during the day.

(Re)Evacuation

Institutions already think ahead. For example that there are possibilities for compartmentation in the institution to keep people inside safe for a longer period of time case of fire. Also, the institution in Kesteren realizes one connection outside the institution to plug in a generator. This can postpone the necessity to evacuate and make disaster management easier.

But when a flood threatens, is an evacuation a logical step? In the case of a healthcare institution, this is difficult to determine, even when the surrounding area will be evacuated. Where flooding will occur and how severe the consequences are is uncertain. This also applies to the time that one has to evacuate. The evacuation of a hospital is a complex operation. The economic and human costs are high as it is always dangerous, difficult and expensive to evacuate large numbers of critically ill clients. It has to be decided if it is worth to take these risks in the light of a possible evacuation. Also, I did not find any regulations regarding re-evacuation. It seems logical that a number of people such as cleaners, owners of supermarkets, electricians etc. are given priority when they return to the area to make it liveable besides making it habitable again, and to restore amenities. How this is done is yet unknown to me. It might influence chaos and expectations of the population upon return. When a flood actually took place, everything is not all at once returned to normal.It pays off to invest in extra floors, amenities and networks so that vulnerable people can stay in the institution.

Awareness

Many people do not seem to realize what dangers the water opposes. Previously you called 112 (or 0611 for that matter) when there was a problem, this was then dissolved by the government. Society has changed, and one can not simply rely on the government to solve everything. We are now in an intermediate stage in which people should become more aware of the need to take action themselves. The vast majority of the people in need is organized. There is contact with institutions, large 80% is in the picture. Of more than 90% of the institutions is known to what extent the planning is already present.

The ideal picture according to the MAAD is that self-reliance is part of the curriculum at primary school. What can I do to protect myself and my environment or to bring it to safety. When awareness is increasing, people naturally come with questions. By strengthening self-reliance and awareness, citizens can reduce the risk of death and injury. Only when the treat is known, the chance of survival can be increased by determining a strategy. The government can strengthen self-reliance by providing information or other measures during a threat. People can see the possible consequences of their actions and take measures for this purpose. The government can also modify the environment so that self-reliant operations can better be performed. By improving the disaster management and strengthening the self-reliance, the number of victims will be reduced.

Vital infrastructure

When one or more routes are not accessible, this will only contribute to further chaos. If dike breaks when people are stuck in traffic jams these people will trapped. So the manner in which the space in the Netherlands is furnished with a view to an evacuation can still use attention. Naturally the Netherlands has a fairly close road network. But the possibilities (regarding location, height and building methods) may not be optimal. More research has been done about making buildings water resistant, but keeping the water out is only half of the problem. For example, I do not know if roads and buildings located further away from the river are designed to withstand high flow velocities. Someone with a civil engineering background might be able to shed some light on this.

What can be done through spatial planning

Redevelopment provides flexibility to adapt the urban area to new circumstances or insights. (Which developments am I allowing at what place?) With this, vulnerability of healthcare institutions can be reduced. As a spatial planner, you can influence the amount of people who live somewhere and economic developments in a area, and hence the amount of damage / casualties. It is important to built healthcare institutions in a location where they will not flood or have more time to evacuate, since the implications are greater. Also, infrastructure for telephone, computer, electricity, water and roads should be taken into account in advance because healthcare institutions rely heavily on this. MAAD advises municipalities to health issues at major events. But they are also involved in spatial planning. MAAD for example thinks along with infrastructure within planning. New neighbourhood? What about the possibilities for medical assistance?

Both spatial planning and water management relate to public space, but are treated by different professionals. In my experience they are more and more working together. The 'WaalWeelde' plan of the Province of Gelderland is a good example of this. Here a large area along the Waal is addressed at once and key aspects of the environment and required future developments are taken into account. This creates a unity in the landscape, which is important from an architectural perspective. It also creates unity in implementation so that multiple parties are involved simultaneously.

Broader perspective

Already some ideas for further research have been opposed above. And although there were some bumps along the roads considering the interviews, I believe that my research actually contributed to understanding the position of non-self-reliant people during a flood. And we arranged it pretty well with some work still to be done. More attention should be given to the things that are related to the provision of care such as vital infrastructures. The MAAD is also doing a good job in trying to increase awareness and assisting in the planning process of all the institutions. But maybe they can use some help in getting all institutions, including home care, involved and aware. It is a big task for such a small organisation.

5.3 Commentary

Methods used

The decision was made to start with a literature review which was a good choice. It showed insight in the problems and the current situation. Getting people to speak with me for the interviews was a great trial. Every time I called, I was transferred. Sometimes, after being transferred a number of times, to get to point where I started off again. I would have liked to interview hospitals in Tiel and Gorinchem. Of the nine approached care arrangements, four have finally participated in my research. This was not only due not knowing who was responsible, but also because vacations had started already. I only got to interview people at three healthcare institutions. The question arises if this is enough. Well I believe it is. All institutions could respond to my questions and referred to their emergency plans and to their responsibilities towards the MAAD. They all more or less said the same. I did not hear any disturbing or very different things while interviewing. Also, all of the people interviewed had several tasks in management as well. The question remains if this is a good thing since they do not focus on only one element. On the other side, they get to manage the institution in a more integral way. Later on I contacted the MAAD of ‘Gelderland Zuid’. They verified that what the institutions told me was true. The things I heard and read about their responsibilities are true as well. The level of preparation differs, but the MAAD is keeping in touch with the healthcare institutions. How things are arranged differs as well, but since plans are tailored to the institution this seems to be a good thing. The platform organized by the MAAD will help them to further develop their plans. Someone could interview more persons from an institution (outside the holidays) to get a more detailed understanding to what extent institutions are prepared. The interviews were elaborated in a simple manner, which makes it harder to compare them.

Remarks Flooding Lizard

Due to the limited time available, a choice for two of the 25 available scenarios had to be made. Within these, a choice could also be made for scenarios in which the partitioning of the Amsterdam Rhine Canal is taken into account or not, and a choice of an exodus of the Amsterdam Rhine Canal (ARC). The final choice is made from the scenarios without partitioning of the ARC; this is because nothing is certain about this issue. This topic is still "pending" at the moment. The final choice was made for Angeren and IJzendoorn for the reasons given in paragraph 3.1.2. A breakthrough in eastern part of dike ring 43 was not adopted because the effect remains limited to the eastern part of the dike ring and less meaningful statements on the westerly part of the area could be made. In addition, the outcome of all scenarios is negative for the eastern part because the water always flows towards this area due to its low-lying location in dike ring 43. The model runs from 0-289 hours; this is a limitation because you do not know how the flooding evolves over time. It is also not possible to click on the colours and see a value, I had to compare these to the legenda myself which makes the values less accurate. Also, these scenarios are only applicable when the breach in the dike is not interim is repaired.

There was no good GIS file available in which the height of roads and tunnels were indicated. As a result, the measured values are less precise. Use was made of the Flooding Lizard in order to determine the flooding of roads. Also, we do not know much about the functioning of vital networks during a disaster like a flood.

Terminology

The terminology of the different disciplines of spatial planning, water management and disaster management differs. They are really separate worlds which make the use of other methods, concepts, definitions and expressions. Especially the methods and shemes used in crisis management are not one on one applicable to either water management or spatial planning. They do not connect to eachother. There were also many Dutch terms which had to be translated. A generic translation could not be found. Also, the different disciplines focus on different scales. These are not always connected to each other. All these things make it more difficult to work together.

6. Reflection on the learning process

Writing a solid and sound theoretical framework for my MSc. thesis.

The theoretical framework was the hardest part of my research. I read a lot of literature and at a given moment I just had to start writing. However I rather know exactly what to do and what it is about. My thesis is about a relatively new field in planning. Making it hard to find direct literature about the subject. My supervisors were a tremendous help in this. Guiding my research in the direction of the concepts needed. From here on the research took off pretty quickly.

Experience a professional working environment.

During my research, I had a place at the Province of Gelderland. This was very interesting because I was allowed to meetings and so gained insight into the field. The people are very nice and thanks to all the help I've been given access to information such as the Lizard flooding program. I would not have been able to manage this had I worked from behind my desk. Sometimes it also was difficult. At one time many people went on vacation, or they came right back. All schedules and enthusiastic stories did not work so well on my concentration. The same was true for the beautiful but sometimes too hot or wet weather.

Improve my scientific writing up to the point that it does not decrease the value of my thesis work.

My scientific writing needed some work. In one of the subject they told me to keep it personal and that using 'I' was allowed and a good thing to do. My supervisors though otherwise. This did not pose a big problem after all. Structuring my thesis was harder. I needed to write more 'to the point' and be more clear in my statements. A lot of time went into rewriting and revisioning my work. This is all part of writing down my thesis, but I found it difficult anyway. But all the work did make my thesis into a better piece of work.

Learn to use more arguments for the statements I make. In my thesis, as well in discussions and meetings with my supervisor and professionals in the field.

Scientific verification was the easy part of my thesis. But writing down the arguments for my conclusions was harder. I went over and over my thesis to get the structure right and to be sure that my conclusions came from the work that I ha done and not from something I read, heard or saw somewhere else along the way.

Gaining knowledge in the field of MLFRM and how water-management, flood protection and urban planning are connected.

The concept of MLFRM is known to me. In the end, MLFRM was only the first step and the cause of my thesis. The research did not comprise this concept only. I know about its possibilities and how is made use of it in the Province of Gelderland. However I believe that more integration between levels and between parts of the government is needed to save valuable time and money in protecting the Netherlands against the water and having enough water available in the future.

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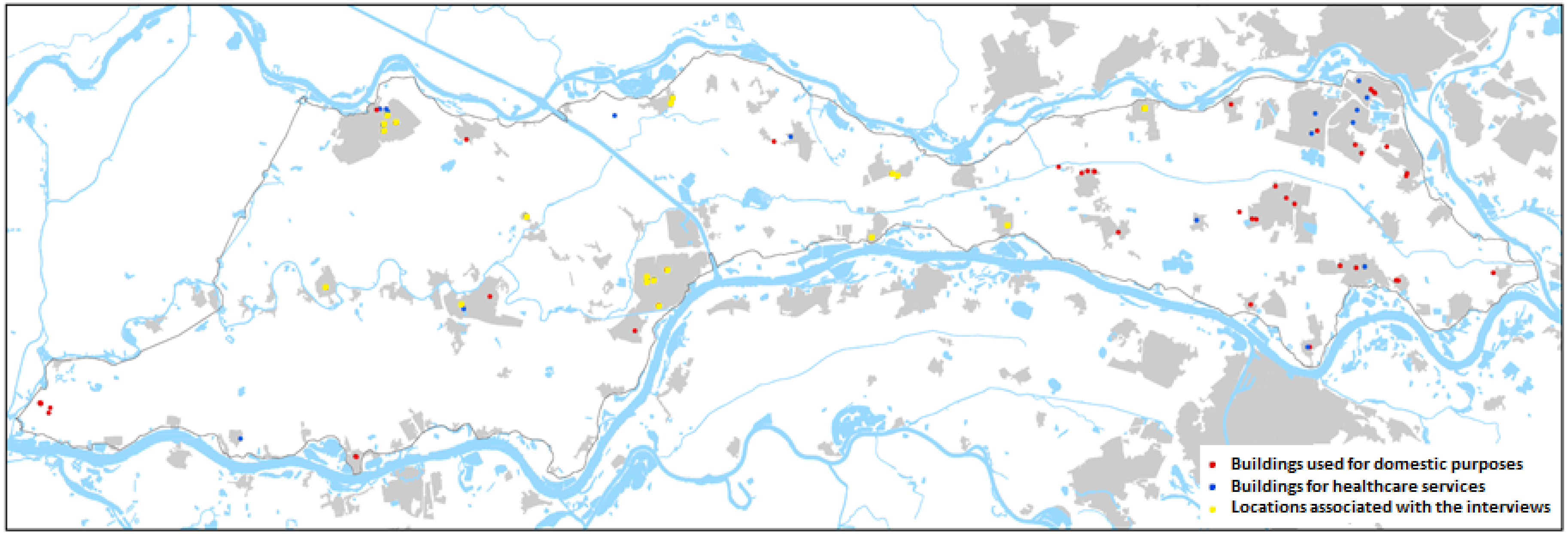
8. Appendices

Annex A: Map with the part of Netherlands that could overflow from the sea or river (dark blue).

(Source: Ministerie van Verkeer en Waterstaat van Floodsite.nl)

Annex B: Overview of the buildings used for domestic purposes (homes, residential complexes for non-self-reliant people and places for the elderly) and buildings for healthcare services (clinics, hospitals and nursing homes) (Created using Risicokaart.nl and GIS by E. Lenselink & G. Perquin, Source: Provincie Gelderland 2013). The yellow dots show the healthcare institutions where interviews are taken.



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