

Bachelor Thesis Delta Management

“Crisis prevention and crisis management in the municipality of Reimerswaal”

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Abstract

Before you lies my Bachelor thesis research, what is written in the period between August 2017 and January 2018. The purpose of this research is to make a clear overview of crisis planning in critical infrastructure sectors and governmental institutions in Reimerswaal and how cascading effects are incorporated in their crisis planning.

This study results from a literature study in combination with a practical study. The report includes data and information what is available for further research.

During the research and writing of this research report, I was guided by Jean Marie Buijs, my in-company supervisor.

This small chapter also serves as a 'thank you' note. A special thanks goes to:

- All the members of the research group Resilient Deltas for their help and feedback
- My in-company supervisor Jean Marie Buijs who supervised this thesis and who took the time to be at hand with help and give advice
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- My family and girlfriend for supporting and helping me during the research period

I would also like to thank the reader for the interest you have shown by reading this document,

Jordy Schelkens

List of Abbreviation

Abbreviation:	Definition:
BT	Beleids Team
CI	Critical Infrastructure
GIS	Geographic Information System
GRIP	Gecoördineerde Regionale Incidenten Procedure
HZ	Hogeschool Zeeland
ILT	Inspectie Leefomgeving en Transport
KPI	Key Performance Indicator
kV	Kilo Voltage
MOTO	Multidisiplinair Opleiden, Trainen en Oefenen
OTO	Opleiden, Trainen en Oefenen
ROT	Regionaal Operationeel Team
RWS	Rijkswaterstaat
VeWin	Vereniging Waterbedrijven in Nederland
VRZ	Veiligheidsregio Zeeland
Wvr	Wet veiligheidsregio

Abbreviations used in the appendices

Abbreviation:	Definition:
GMK	Gemeenschappelijke Meldkamer
ROT	Regionaal Operationeel Team
ROL	Regionaal Operationeel Leider
RBT	Regionaal Beleids Team
GBT	Gemeentelijk Beleids Team
CoPI	Commando Plaats Incident
VR	Veiligheidsregio
WAT	Waterschap Actie Team
WOT	Waterschap Operationeel Team
WBT	Waterschap Beleids Team
OT	Operationeel Team
OL	Operationeel Leider
NCC	Nationaal Crisis Centrum
CvdBw	Commandant Brandweer
SitRap	Situatie rapport
Caco	Calamiteiten Coordinator

Summary

Introduction

The research group of the Hogeschool Zeeland has set up a consortium to develop new knowledge about cascading effects in critical infrastructure in the event of a flooding; as well as measures in pro-action, response and recovery phases to help the involved professionals increase the resilience of society. The municipality of Reimerswaal is indicated as research area, because it is a relative narrow piece of land containing a large variety of critical infrastructure (CI). The Resilient Deltas research group needs to have a better overview of the crisis management plans of the CI sectors in order to develop new knowledge about cascading effect in the CI sectors.

The goal of this research is gain knowledge and insight of how crisis management is organised in CI sectors and governmental institutions in relation to cascading effect, in the municipality of Reimerswaal. The crisis documents must be analysed throughout documentation research and interviewing the responsible experts of the CI sector. This shows how well CI sectors organised their crisis management plans and if cascading effects are incorporated in the crisis plans. The crisis management plans can give an indication how well resilient a sector is against sudden disruptions and cascading effects in their system.

Methodology

The scope of this research focuses on three CI sectors (electricity-, drinking water- and flood risk management sector) as well as two governmental institutions (Veiligheidsregio and the municipality Reimerswaal) in the municipality of Reimerswaal. The research methodology consists out of multiple methods; desk research, semi-structured interviews and participation and observation in workshops. The use of different methods both increases the validity of the data and the view on the subjects.

Results

The regional risk profile forms the basis for preparation of crisis management within the Veiligheidsregio Zeeland (VRZ). The goal of the regional risk profile is to prevent risks, but if the risks are escalating, limiting the risk as much as possible. In total, it is about 23 multi-disciplinary plan figures including 14 disaster control plans for companies. The VRZ made an incident or risk map where all risky locations and vulnerable objects are put into. The risks are put into seven themes including the natural environment theme which includes a flooding crisis type. The risk map is taking into account three flooding probabilities within the VRZ. With this information, the VRZ makes a risk image of each individual municipality in the province of Zeeland. Municipalities like the municipality of Reimerswaal, have to implement and coordinate the plans on local scale. The municipality of Reimerswaal assumes the CI sectors keep their crisis management plans up to date.

Water board Scheldestromen has six separate crisis plans regarding their broad amount of tasks, however the plans taken in conjunction with the overall crisis plan of Scheldestromen. The overall crisis plan is the general crisis plan of the water board including the general crisis structure and measures during a crisis.

Evides develops a delivery plan based on disruption risk analyse. The analyse takes around fifty different scenario's into account, including a flooding scenario.

Enduris has another approach considering risks compared with the other sectors, called asset management. Crisis management is included in the asset strategy of Enduris and includes a flooding scenario.

Crisis measures, such as scenario planning, crisis communication, information management, Gecoördineerde Regionale Incidenten Procedure (GRIP), evaluation and covenants are represented in all the CI sectors and governmental institutions. The governmental institutions and CI sectors have similar crisis measures. Every sector has its own measures to react, response and recover to and from a crisis. The CI sectors and governmental institutions are the specialist in their own field and know what crisis measures are best.

A cascading failure is an indirect consequence of a flooding event. If the cascading effects are known, organisations can adapt their crisis management plans in order to deal with or limit the impacts of cascading effects. The identified measures against cascading effects in the studied sectors can be seen below.

Organisation	Measures against cascading effects
VRZ	GIS mapping including crisis scenarios
Municipality Reimerswaal	GIS map of VRZ
Water board Scheldestromen	Mapping cascading risks and infrastructure research
Evides	Emergency water procedure and joint tool usage
Enduris	Smart usage of infrastructure and infrastructure research

The Multidisciplinair Opleiden, Trainen en Oefenen plan (MOTO) of the VRZ is developed every four years. The MOTO is put into an annual year calendar consisting of training, exercising and education. The VRZ has to do a policy team exercise with every municipality once a year. The municipality of Reimerswaal is exercising a realistic scenario together with the VRZ.

The crisis management plans at Scheldestromen are tested on a regular basis with a multi-year policy plan. The policy plan describes the way in which the organisation prepares for crisis in the next four years by means of training, education and practising. The multi-year policy plan consists out of an annual program with proposed activities and exercises.

The crisis management procedure of Evides is tested on a regular basis –twice a year- with operational exercise and multi-disciplinary exercises. Evides is also exercising with a large variety of organisations and governmental institutions, such as the municipalities.

Enduris is practising crisis scenarios in a simulation room. The simulation room is used to test crisis scenarios and in order to improve the preventive measures of their crisis management. Enduris is intensively exercising with the VRZ whereby the crisis line is tested

Conclusion

This qualitative research concludes that the crisis management plans enhance the resilience of the critical infrastructure sectors and governmental institutions. The cascading effects of other critical infrastructure sectors are identified and taken into account as much as possible.

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1. Introduction

A flooding is an undesirable event, but such an event cannot be excluded, not even in the Netherlands. By taking protective measures it is ensured that a flooding event does not occur often. However a flooding is not fully preventable. The Delta Programme Spatial Adaption focuses special attention on this, because a flooding may cause a failure of essential facilities and services causing, such as critical infrastructure (CI). The Netherlands specifies the distinction between opportunities and consequences as a basis for a policy called multi-layer safety, introduced in 2008. The overarching goal of the multi-layer safety approach is to reduce the chance of flooding and its consequences to an acceptable level and is used in the Delta Programme Spatial Adaption (Delta Commissaris, 2017).

The approach is a method to reduce the flood risk to an acceptable level, however a flood cannot be excluded. Therefore two other layers are included in the approach to reduce the impacts of a flooding, namely sustainable spatial planning and crisis management (Kolen, Maaskant, & Hoss, 2011).

The research group of the Hogeschool Zeeland (HZ) has set up a consortium with the province of Zeeland, municipality of Reimerswaal, Veiligheidsregio Zeeland, Rijkswaterstaat (RWS), water board Scheldestromen and Deltares. The goal of this is to develop new knowledge about cascading effects in CI in the event of a flooding; as well as measures in pro-action, response and recovery phases to help the involved professionals increase the resilience of society. The municipality of Reimerswaal (see figure 1) is indicated as research area, because it is a relative narrow piece of land containing a large variety of CI. The research is being conducted in the period from 01.02.2017 to 31.01.2019. The Resilient Deltas research group needs to have a better overview of the crisis management plans of the CI sectors in order to develop new knowledge about cascading effect in the CI sectors.

This Bachelor thesis was conducted within the Resilient Deltas research group of the HZ University of Applied Sciences located in Vlissingen. This study focuses on researching the crisis management plans of CI sectors and governmental institutions in Reimerswaal, because the research group Resilient Deltas does not have a clear overview of the CI sectors crisis management plans.

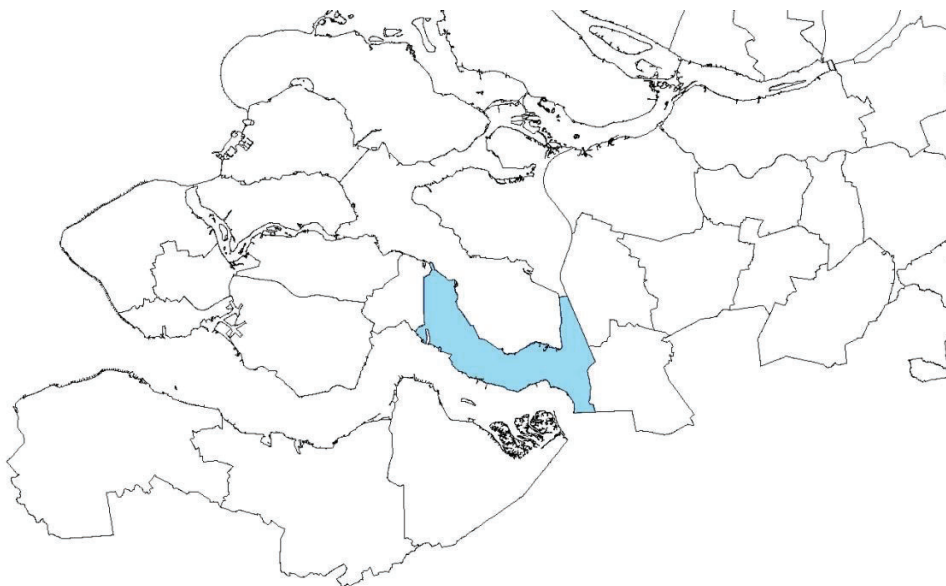


Figure 1: The municipality of Reimerswaal. (Source: Personal collection)

1.1. Background

The Reimerswaal municipality is located in the province of Zeeland in the southwestern delta of the Netherlands (figure 1). The municipality is a small portion of the province yet the municipality is of great importance. Reimerswaal is a narrow piece of land that is connecting large parts of Zeeland with the mainland of the Netherlands. Moreover, a large amount of CI is situated in and crosses the Reimerswaal municipality (Provincie Zeeland, 2016). The area of Reimerswaal is a low lying piece of land that has a potential threat of flooding (see appendix I) (Algemene Hoogtebestand Nederland, 2017).

The risk of a potential flooding is increased by the changing climate what is leading to more extreme weather with extreme precipitation events and a rising sea level (Kik, 2014). By 2100, the sea level is likely to rise between 35 and 85 cm while the annual precipitation is likely to increase with six percent in the Netherlands (van Minnen, et al., 2012). In addition, pieces of land can subside due to groundwater extraction and the composing of peat in the soil (Kooi, 2000). The combination of these three factors (low lying area, climate change and land subsidence) leads to an increasing risk of flooding. A flooding in a delta area can have two causes:

- The first cause can be a failure in the first prevention layer in other words a dike protection failure. This can occur when a the prevention layer is not prepared for a heavier storm than calculated as the norm;
- The second cause can be heavy precipitation what is results in a flooding (van Minnen, Ligtoet, Franken, & van Bree, 2012).

The municipality of Reimerswaal contains large CI networks, like drinking water infrastructure or electricity infrastructure. The networks that cross the municipality of Reimerswaal provide basic needs for a large part of the Zeeland province. The CI sectors are vital for the everyday activities of the population of Zeeland. CI is often interconnected with each other, or in other words is independent on each other. A disruption of CI sectors can lead to cascading effects on other infrastructures and affect the community of Reimerswaal and Zeeland (Insituut Fysieke Veiligheid, 2017).

The cascading effects can affect different sectors of Zeeland and impact the daily life of many inhabitants and companies (Buijs, Hounjet, & Fundter, 2016). The different CI sectors try to minimize the effects of a disruption and prepare flexible measures if such a scenario should happen. This is known as crisis management plans what an essential part of the multi safety approach is. Crisis management includes pro-action, prevention, response and recovery measures. The phases include the protection of CI sectors from damage as well as recovery measures for the recovery of the infrastructure. The most important part of crisis management is the learning process or the mitigation phase of crisis management (Vanneuville, Kellens, Maeyer, Reniers, & Witlox, 2011). A good crisis management approach can increase the resilience of an organisation or sector, because it includes better crisis preparation, response and recovery measures. (Kolen & Wouters, 2007).

1.2. Problem Formulation

The crisis management plans are essential to know, because the plans give an indication of how resilient a sector is against a flooding scenario. However, Resilient Deltas has not a clear overview of the different crisis plans from the CI sectors in the Reimerswaal municipality. An overview of the crisis management plans will help the research group to measure the resilience of the CI sectors in Reimerswaal. The crisis documents must be analysed throughout documentation research and interviewing the responsible experts of the CI sector. This shows how well CI sectors organised their

crisis management plans and if cascading effects are incorporated in the crisis plans. The crisis management plans can give an indication how well resilient a sector is against sudden disruptions and cascading effects in their system. (Boin & McConnell, 2007).

1.3. Research Questions

1.3.1. Central Question

The central research question is stated as followed:

“In what way does crisis management enhance the resilience of the critical infrastructure and government institutions in relation to cascading effects of a possible flooding scenario in the municipality of Reimerswaal?”

1.3.2. Sub-Questions

The sub questions are building up the central research questions and answer separate parts of the research question.

The CI sectors face different threats including a possible flooding. It is likely that a sector has a crisis plan already, but it is important to know how the crisis plans look like and how a sector would react in case of a flooding caused by a prevention failure or extreme precipitation. Therefore, it is important to know;

What crisis management plans have the different critical infrastructure sectors and governmental institutions have in case of a flooding scenario?

Crisis management planning consists out of four stages; preparation, response, recovery and prevention & mitigation. The different stages show a certain sector plan their preparations, responses, recovery actions. Therefore it is important to know:

How are the crisis management phases represented in the different critical infrastructure sectors and governmental institutions plans?

As mentioned before, cascading effects can have serious consequences for sector(s) or a community. Therefore, it is important to know:

How are the cascading effects incorporated in the crisis plans of critical infrastructure sectors and governmental institutions?

A crisis with cascading effects can affect multiple sectors at once and cooperation is therefore essential to overcome a crisis. Therefore, it is important to know:

How are the critical infrastructure sectors and governmental institutions collaborating, such as preparing and exercising, in terms of crisis plans for a possible flooding scenario?

1.4. Research Objective

The following research objective has been formulated:

The goal of this research is gain knowledge and insight of how crisis management is organised in critical infrastructure sectors and governmental institutions in relation to cascading effects, in the municipality of Reimerswaal.

The scope of this research focuses on three CI sectors (electricity-, drinking water- and flood risk management sector) as well as two governmental institutions (Veiligheidsregio and the municipality Reimerswaal) in the research area. The three sectors are chosen, because of their major importance in the area of Zeeland for citizens and economic activity. The two governmental institutions are chosen because, Veiligheidsregio Zeeland (VRZ) is responsible for the physical safety (crisis

prevention and crisis management) of Zeeland and the municipalities have to implement this on local scale. Chapter 3.3 "Research scope" gives a further explanation of the research scope.

1.5. Report layout

This thesis starts with an introduction about the conducted research. This is followed by chapter two, where the theoretical framework is explained which is serving as background information as well as understanding where the problem arises and to explain the concepts and definitions in detail. In chapter three the methodology used during this research is described.

Chapter four contains the results of the applied research methods from the chosen CI sectors. The result chapter is subdivided according to the sub questions. The fifth chapter contains the discussion and explains the strengths and limitations of the research. The final chapter concludes with the answers to the sub-questions and the main research question and gives further recommendations for future research.

2. Theoretical Framework

2.1. Resilience and the multi-layer-safety approach

Recent events like hurricane Katrina in 2005, hurricane Harvey and hurricane Irma in 2017 show what extreme weather can cause to CI (Vallejo & Mullan, 2017). There is a notable shift in emphasis from protecting CI and emphasis on a resilient community since hurricane Katrina. New ideas and concepts of resilience pave the way into policy and implementation (O'Rourke, 2007). Resilience is the ability to recover from a certain impact, so a society can better process the impacts of a disruption that is disordering the daily life of the society (Fundter, et al., 2015). An example of the emphasis of resilience in the Netherlands is the introduction of the multi-layer safety approach.

Since 2008, the national government of the Netherlands is using a multi-layer safety approach to increase the sustainability of the water safety policy and stimulate cooperation between regional parties. The multi-safety layer approach is an integrated approach that stimulates resilience and singularity of parties or organisations. The approach is a method to reduce the flood risk, prevention; however a flooding is not always preventable. Therefore two other layers are included in the approach, namely sustainable spatial planning and crisis management (Delta Commissaris, 2017). The multi-layer safety approach is required in order to avoid future rising of the flood protection and to minimize damage considering with pluvial flooding's due to heavy rainfall (Delta Programme Commission, 2016). The multi-layer-safety approach consists out of three layers;

1. Prevention layer;
2. Sustainable spatial planning layer;
3. Crisis management layer.

2.1.1. Prevention layer

The first layer focuses on prevention of a flooding wherever possible with solid dikes, sand replenishment or more room for the rivers. The Netherlands has a system of dike rings with a high standard that prevent flooding's. The safety level of the prevention layer is determined on a cost and benefit analyse what includes a victim analyse based on the flooding chance. The safety norm is stricter at areas with greater chances and consequences of a flooding. The safety norm around the Randstad, the economic heart of the Netherlands, is different compared with Zeeland. This is because the Randstad has a larger population and a higher economic value compared with Zeeland. The dike system is tested every six years and followed by an improvement program if the dike system is not safe enough. The safety norms for the dikes are changing at a continuous rate, because of new climate models (Kolen, Maaskant, & Hoss, Meerlaagsveiligheid: Zonder normen geen kans, 2012).

2.1.2. Sustainable spatial planning layer

The second layer is sustainable spatial planning. The Netherlands is famous for its spatial planning and water has been taken into account in the spatial planning. This refers to spatial planning that is addressing multiple purposes, for instance, water storage can be combine with recreation or nature conversation. Spatial is an attractive way to deal with flood risks while taking into account other purposes as well (Kolen, Maaskant, & Hoss, Meerlaagsveiligheid: Zonder normen geen kans, 2012).

2.1.3. Crisis management layer

The third layer is crisis or disaster management. Crisis management refers to coordination between emergency providers and parties responsible for specific services. The third layer aims for a better co-ordination between partners and control of emergency services. This will not only have a positive effect on the crisis management itself, but will make it easier to recover after an area has been struck

by a disaster or crisis. Crisis management is thus an important aspect of resilience (Kolen, Maaskant, & Hoss, 2011). Investigating the crisis management gives an indication how resilient a sector is against sudden disruptions, like a flooding (Boin & McConnell, 2007). The next subchapter will give further explanation of crisis management.

2.2. Crisis management

Crisis management consists of preparation -, response -, recovery and prevention methods to minimize the impact of a possible crisis. A crisis management cycle considering flooding scenario's or threats is considered as flood risk management, however the same cycle is adapted (Bundy, Pfarrer, Short, & Coombs, 2016). The crisis circle is divided into four phases; -, preparation -, response -, recovery and prevention methods, visualized in figure 2.

Preparation is to take away the causes of an unsecure situation before they happen. (Vanneuville, Kellens, Maeyer, Reniers, & Witlox, 2011). Crisis experts agree the key to being resilient is preparation. The set of skills and deep knowledge of operations can help organisations prepare for a crisis and make an organisation ready to resist, react and recover from a disruptive event. By being pro-active and understanding the risks, the organisation develops a level of comfort when a crisis occurs that people will understand instead of being worried. That does not mean to just create a crisis plan. In a world with constant changing factors, it is important to have integral crisis management plan. Hereby, every layer of the organisation knows what to do and what to expect in course of action (Agnes, Lukaszewski, Parra, & Rapa, 2017).

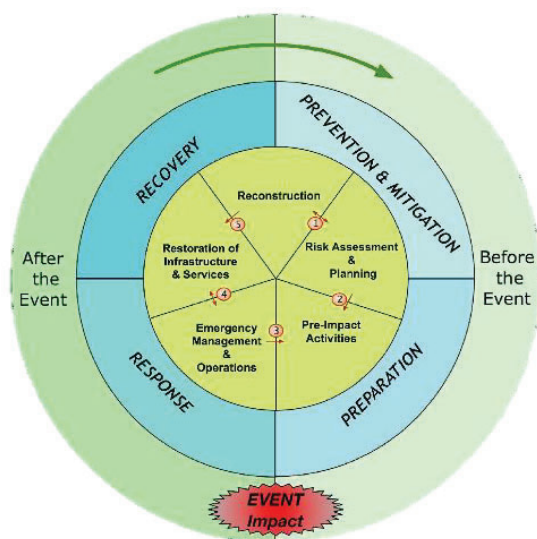


Figure 2: The crisis management cycle. Source: (Vanneuville, Kellens, Maeyer, Reniers, & Witlox, 2011)

After a disruptive event occurs, the phase response is being executed. The response phase consists of emergency management and emergency operations to save lives and to protect important assets. One of the most important aspects of reaction is internal and external communication about what happened and what are the next steps. Informing about the problem and the remedial action can avoid panic and confusion and stimulate the recovery thus the resilience (Agnes, Lukaszewski, Parra, & Rapa, 2017).

The recovery phase encompasses measures to bring back the old situation as fast as possible, like repairing infrastructure networks and repairing special services. Recovering the infrastructure as fast as possible can improve the recovery phase while critical services are back available. When the impacted region is fully recovered and back in the old state, the cycle shifts to prevention and mitigation (Vanneuville, Kellens, Maeyer, Reniers, & Witlox, 2011).

Post crisis actions help an organisation in the future to improve the crisis resilience by including lesson learning and documentation. By incorporating these experiences into the plan, the organisation can move closer to being resilient. The experiences are put into new prevention measures which are more resilient to new crisis (Agnes, Lukaszewski, Parra, & Rapa, 2017).

A crisis resilience plan is in place when it:

- Includes all key functions within the organisation;
- Identifies all key stakeholders and methods for internal and external communication;
- Identifies key risk scenarios and specific response procedures;
- Is communicated and understood throughout the organisation;
- Is tested on a regular basis, following periodic testing and sharing of results;
- Is relevant to the network and the stakeholders;
- Provides procedures for post-crisis review and lesson learning (Agnes, Lukaszewski, Parra, & Rapa, 2017).

A way to reduce possible socio-economic damage by disruption effects is collaboration on crisis management level. Collaboration is essential for a well working CI system (Buldyrev, Parshani, Paul, Stanley, & Havlin, 2010). The Netherlands has a national agreement considering the crisis and disaster management, called GRIP (Gecoördineerde Regionale Incidentenbestrijdings Procedure). The GRIP procedure regulates the upscaling on the operational level of an organisation (see table 1).

The goal of the GRIP is to regulate the upscaling between emergency services and municipalities within Veiligheidsregios of the Netherlands (Cools, Wijkhuijs, & van Duin, 2017). The Netherlands is divided into 25 parts concerning crisis management. This is called a “Veiligheidsregio” or Safety Region in English. The safety region is a collaboration network that includes disaster- and crisis management, emergency services, public security and public order of a region. The Veiligheidsregio is a critical player in terms of making and updating and communicating crisis management plans between CI sectors and governmental institutions. The municipalities under the Veiligheidsregio region have to implement the crisis management plans on a local scale. (Ballin, 2017). The GRIP procedure is developed in order to scale up easily and quickly. Upscaling means that more equipment and men power is used to combat against the crisis and to minimize escalating and cascading effects of a certain disruption. When a disruption is affecting a bigger region, organisations can scale up to minimize the socio economic damage (Instituut Fysieke Veiligheid, 2011).

GRIP Phase	Explanation of each phase
One	Source control of the accident, an incident of limited impact.
Two	Source- and effect control. The incident has a clear impact on the surrounding environment.
Three	There is a threat to the citizen wellbeing inside one municipality.
Four	The threat is escalating and covers multiple municipalities.
Five	A disaster or crisis what strikes multiple “Veiligheidsregios”.
Rijk	A disaster or crisis where different government ministries (Rijk) are concerned.

Table 1: The six GRIP phases. Source: (Cools, Wijkhuijs, & van Duin, 2017)

2.3. Critical infrastructure

Infrastructure provides the basic needs for a well-being nation or region. Infrastructure like roads, waterways and telecommunication provide citizens and companies with basic needs for everyday life while other kind of infrastructure protect and connect the region where citizens and companies accommodate (Rinaldi, Peerenboom, & Kelly, 2001). The infrastructure does not only connect, but also keeps a region competitive and attractive for economic activities and tourism. CIs on the other hand are the products, services and processes that are vital for everyday life, like water, electricity. When CI is disrupted, it can cause great social economic damage, because CI is most of the time interconnected with each other. The community who is dependent on CI can be greatly affected by such a disruption. The society of today is highly dependent on CI while society expects that CI keeps

performing 24 hours a day (Addae, Hebbink, & Hamelink, 2015). The CI is divided into different sectors according to the services or goods the sectors provide (see appendix II). A brief overview of the CI and their services is included in table 2.

Critical sectors and their critical products/services	
Sector	Product or service
Energy	National electricity transport and distribution
Energy	Regional distribution electricity
Energy	Regional distribution gas
Energy	Oil supply
ICT/Telecom	Internet and data services
Financial	Communication with and between emergency services via 112 or C2000
Public order and safety	Deployment police
Water	Water quantity management

Table 2: The critical sectors and their critical products or service. Source translated from: (Ministerie van Veiligheid en Justitie, 2017)

2.4. Interdependencies

As mentioned in the previous paragraph, a small failure inside a CI sector can impact a great amount of people. This is because the CI sectors are interconnected with each other. This is called interdependencies. The interconnection between the sectors is called interdependency. The state of one infrastructure sector can influence the state of other infrastructure sectors or to simply when two types of infrastructure are dependent from each other (Rinaldi, Peerenboom, & Kelly, 2001). A sector can thus be influenced by its surrounding structure and this can be positive but also negative (figure 3). When all surrounding sectors work well, the sector performs maximum, but when a disruption occurs in the surrounding system, the sector can be influenced by the disruption. For instance, the energy sector has a failure inside their system, the drinking water sector is affected as well, because the water supply system cannot function anymore (see appendix III). A drinking water company has a back-up generator, but such a generator is most of the time a short term solution. A long energy disruption can lead to severe damage and even casualties. Although such failures are quite rare, these failures can have major consequences for humans and economic activities. The amount socio-economic damage depends on what kind of failure is disrupting the system (Buldyrev, Parshani, Paul, Stanley, & Havlin, 2010).

2.5. Cascading effects

The amount of socio-economic damage depends on what kind of failure is causing a disruption. There are three types of failures:

1. Escalating failure;
2. Common failure;
3. Cascading failure.

An escalating failure occurs when an existing disruption in one infrastructure sector exacerbate a disruption in another infrastructure sector. For instance, a failure in the electricity sector causes that the information sector is affected, but the information sector is not fully down. The weakened information sector also affects other sectors in the system like internet traffic (Laprie, Kanoun, & Kaaniche, 2006). The second type of failure is a common failure.

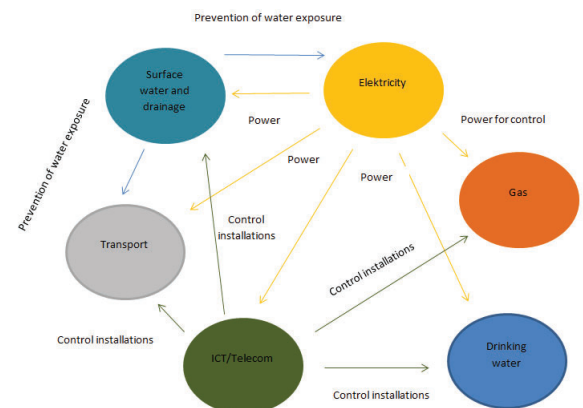


Figure 3: Interdependencies in CI sectors. Source translated from: (Instituut Fysieke Veiligheid, 2017)

A common failure is a failure when two or more infrastructure sectors are affected simultaneously. This can for example happen when hurricane strikes a region and affects multiple infrastructure sectors at once. An escalating or common failure can lead to a cascading failure as well (Pescaroli & Alexander, 2015).

A cascading failure occurs when one system is disrupted other sectors will experience a disruption as well. A failure can become worse as it affects multiple sectors at once. A cascading failure is an indirect consequence of a disruptive event, because it is causing a chain reaction in other sectors (Stowa, 2017). A clear and relevant example is the electricity blackout in Amsterdam of 2017. A small short circuit in the electricity line caused a cascading effect in the energy infrastructure. This caused a cascade effect on other sectors as well. The traffic around Amsterdam was in chaos, trains could not drive and hospitals could not function normally. After a few hours the electricity blackout was solved, but the society around Amsterdam needed a few hours more to function normally again (Stokmans & Logtenberg, 2017). Cascading failures situations are rare; however such situations can influence many sectors and disrupt large communities.

The Circle approach of the Deltares Company is an analyse method that analyses the possible cascading effects when CI is failing in a certain area. The Circle approach is following a stepwise approach whereby information is gathered to make a risk assessment with a risk map. Although this advanced modelling is not new, the Circle approach is more detailed and visualizes different scenarios in an interactive map (Deltares, 2015). The consortium of the Hz, province of Zeeland, municipality of Reimerswaal, Veiligheidsregio Zeeland, RWS, water board Scheldestromen uses the Circle method to identify the cascading effects in the municipality of Reimerswaal (Buijs, Hounjet, & Fundter, 2016).

If the cascading effects are known, organisations can adapt their crisis management plans in order to deal with cascading effects. A better crisis management plan leads to a more resilient organisation what can deal with cascading effects in their system (Boin & McConnell, 2007).

2.6. Conceptual Model

Figure 4 below shows the conceptual model of the theoretical framework.

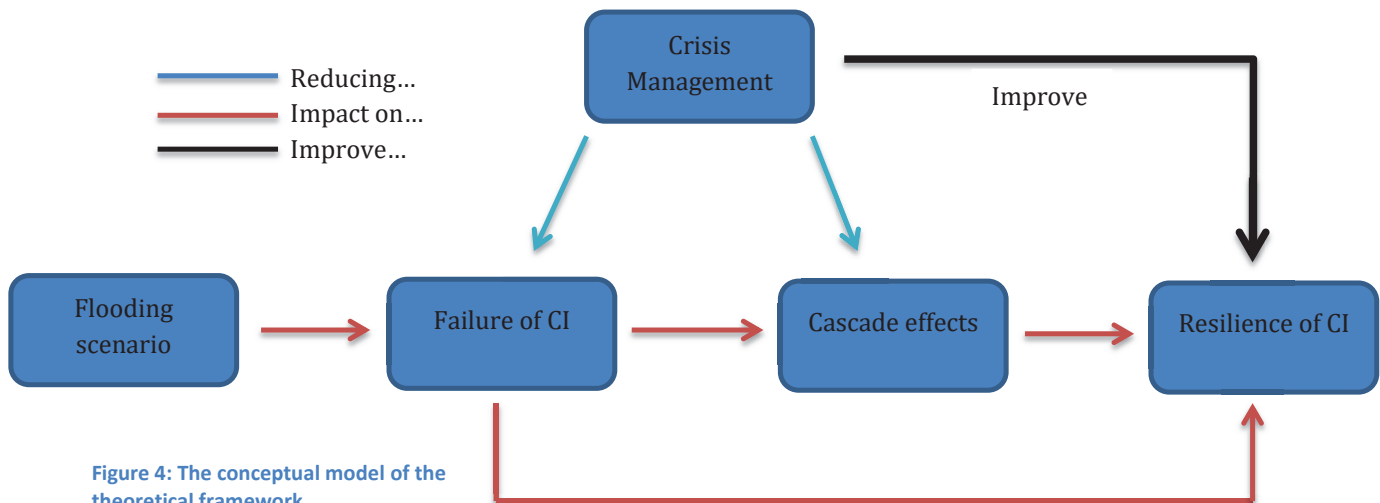


Figure 4: The conceptual model of the theoretical framework.
(Source: Personal collection)

The national government of the Netherlands is using a multi-layer safety approach to prevent a flood risk; however a flooding is not always preventable (**flooding scenario**). A flooding may cause failure

of essential facilities and services causing, also known as critical infrastructure (**Failure of CI**). CI's are the products, services and processes that are vital for everyday life, like water, electricity or flood risk management. When CI is disrupted, it can cause great social economic damage, because CI is most of the time interconnected with each other. The interconnection between the sectors is called interdependency. When a disruption occurs in an interdependent system, a sector can be influenced by the disruption in the other system. This is called a **cascading failure**. A cascading failure is an indirect impact of a CI failure. A power outage causes disruption in the drinking water sector or pumping stations can no longer be controlled. A cascading failure occurs when one system is disrupted other sectors will experience a disruption as well. A cascading failure has an impact on the **resilience of CI**, because a cascading effects cause the disappearance of CI thus making it less resilient. A failure of CI can also have a direct impact on the resilience of the CI, because there is damage to buildings, loss of products or damage to infrastructure.

Crisis management can reduce the impacts of a flooding on CI and cascading effects. Crisis management refers to coordination between emergency providers and parties responsible for specific services. Crisis management consists of preparation -, response -, recovery and prevention methods to minimize the impact of a possible crisis. The set of skills and deep knowledge of operations can help organisations prepare for a crisis and make an organisation ready to resist, react and recover from a disruptive event. Post crisis actions help an organisation in the future to improve the crisis resilience by including lesson learning and documentation. By incorporating these experiences into the plan, the organisation can move closer to being resilient. The experiences are put into new prevention measures which are more resilient to new crisis. Hereby the failure of CI and the cascading effects can be minimized, because the organisation has a more resilient crisis plan what is enhancing the reaction and recovering of the organisation.

3. Research methodology

This chapter mentions the research methodology. The research methodology is essential for the later analyses and to provide conclusions and recommendations and ensure the validity of the research.

3.1. Research Design

This research has a qualitative research design. The chosen approach is the most appropriate approach, because:

- The goal of this research is to get insight in different perspectives of different organisations;
- The research is rather complex, making it difficult to use quantified methods;
- The timeframe of the research is limited, making it difficult to use large scale data collection methods and quantitative methods.

3.2. Methodology

The data collection process is making use of multiple methods. The use of different methods both increases the validity of the data and the view on the subjects. The different data collection methods used:

- Desk research;
- Semi-structured interviews;
- Participation and observation in workshops.

3.2.1. Desk research

Desk research or documentation research is the main part of gathering information for the research. Extensive desk research has been done:

- Scientific articles and reports are reviewed from different databases;
 - Google Scholar;
 - ResearchGate;
 - Sciencegov.
- Documentation received from the research group Resilient Deltas;
- Documents and reports from different Dutch governmental agencies;
- Documentation from interview partners.

3.2.2. Semi structured interviews

Interviews are a qualitative research method which involves individual questioning with a small number of respondents. During the research timeframe, semi structured interviews with seven professionals were conducted. The interviewees can be seen in table 3.

Interviewee	Expertise	Organisation
Marco de Feiter	Crisis Coordinator	Water board Scheldestromen
Wim Huissen	Advisor Public Safety	Municipality Reimerswaal
Lydia Barm	Advisor Strategy	Evides
Patrice Troost	Specialist muliti-disiplinary planning	Veiligheidsregio Zeeland
Wil Zweemer	Asset Manager Processes	Enduris
Wouter de Neijs	Asset Manager Electricity	Enduris
Kristiaan Minderhoud	Asset Manager Electricity Medium Voltage Infrastructure	Enduris

Table 3: The list of all the interviewees. (Source: Personal collection)

The interviews contain a set of questions to be answered with additional open questions. The additional questions are open and therefore expanding the interview scope. The interviews are recorded and the results of the interview are incorporated in the result chapter. The question list of the interviews is shown in appendix IV. Due to privacy reasons, the answers are not shown or included in this appendix. The interviews are shown in Dutch, because the interviewees are Dutch. The results of the interview can visualize how the theory is applied in the practise if the practise is deviate from the theory. The data results from the interviews are subsequently used for the analyses and the conclusion regarding crisis management in the CI sectors.

3.2.3. Participation and observation in workshops

The research group Resilient Deltas already have workshops planned with potential stakeholders of the consortium. The workshops are held between September 2017 and in February 2018. The workshops what contributed to this research are:

- Workshop in Reimerswaal on the 26th of September 2017. The workshop is with Deltares to get an insight of the interdependencies of CI sectors in the process to identify cascading effects.
- Workshop in Borsele on the 22nd of November 2017. The workshop is a climate test in the municipality of Borsele and has at first sight nothing to do with Reimerswaal. However, observations can be made how CI sectors share their information in Borsele.

The workshops are used as observation moments and to observe experts from the chosen sectors. During the observations it can be seen how CI sectors and governmental institutions collaborate and share information with each other concerning crisis planning and identification of cascading effects.

3.3. The scope of the research

The scope of the research is conducting research towards the CI sectors and the governmental institutions in the municipality of Reimerswaal. Chapter 2.2 mentioned and explained all the CI sectors present in the Netherlands. However, it is not possible to conduct research towards all of the CI sectors within the time frame of the research. Therefore, a decision has been made to conduct research to specific CI sectors. The decision has been made after the first workshop in September whereby most of the stakeholders were present. The workshop gave insight which CI sector was most necessary to conduct research to. The selection of the CI sectors was in consultation with the research group. The following CI sector came out of the consultation as result of the workshop:

- The electricity sector (Enduris);
- The drinking water sector (Evides);
- The flood risk management sector (water board Scheldestromen).

This research is also taking into account governmental institutions. The government structure consists out of numerous of stakeholders. The choice has been made to conduct research towards the “Veiligheidsregio”, because this organisation represents all the governmental institutions and is responsible for crisis prevention and crisis planning in the province of Zeeland.

4. Results

The research focuses on two governmental institutions and three CI sectors. The two governmental institutions are the Veiligheidsregio Zeeland and the municipality of Reimerswaal and the three CI sectors are the drinking water-, electricity- and flood risk management sector. The result chapter contains the results and the chapter is subdivided according to sequence of the sub questions.

4.1. The flooding scenario crisis plans

This sub paragraph will go into detail what crisis management plans have the different CIs have in case of a flooding scenario.

4.1.1. Governmental institutions

Veiligheidsregio Zeeland

As stated in the theoretical framework the Veiligheidsregio is a collaboration network that includes disaster- and crisis management, emergency services, public security and public order. The Veiligheidsregio Zeeland (VRZ) is responsible for the physical safety of Zeeland residents, visitors and organisations and thus also the physical safety of Reimerswaal (Veiligheidsregio Zeeland, 2015).

The VRZ establishes a risk profile (in accordance with the established requirements of the Wet van de Veiligheidsregio (Wvr.) Art. 15) and updates it if necessary once every four years, whereby all relevant vital partners are informed and asked to contribute (Wvr, art. 46) (Ministerie van Veiligheid en Justitie, 2016). The Regional Risk profile forms the basis for preparation of crisis management within the VRZ. The VRZ encounters a variety of risks from ICT systems to diseases to flooding's. All the possible risks are stated in the regional risk profile. The goal of the regional risk profile is to prevent risks, but if the risks are escalating, limiting the risk as much as possible. In total, it is about 23 multi-disciplinary plan figures including 14 disaster control plans for companies.

The VRZ invites at least once a year the possible disaster and crisis concerned parties to joint consultation about the risk in the region. This is obligated and is stated in the Wvr, art. 5. The meetings are used to acquire information and data what can be used in the regional risk profile. The VRZ made an incident map where all risky locations and vulnerable objects are put into. The risk chart gives a clear overview of the risks present in the province of Zeeland (Veiligheidsregio Zeeland, 2015). The national guide of regional risk profile states four steps in order to make a regional risk profile:

1. *Risk inventory*: the relevant risks are fully inventoried. This is supplemented with information, such as information about the CI;
2. *Risk chart*: the context and the spread of risks are further explained and visualized;
3. *Risk analyse*: the selected scenarios are determined on the probability of the risk and the impact of the risk. This is done on the basis of expert judgements;
4. *Result of the risk analyses*: the results of the risk analyse are put into a risk diagram.

The risks are put into seven themes and can be seen in appendix V. The first theme includes the natural environment theme which includes a flooding crisis type. The flooding crisis type is subdivided into three incident types, visualized in table four:

Crisis type	Incident type
Flooding	Flooding from the sea
	Flooding as result of high water level from rivers
	Dike system failure/flooding of a polder

Table 4: The incident types of the flooding crisis type. Source: (Veiligheidsregio Zeeland, 2015)

The incident types of the flooding crisis types are put into a risk map to show which locations are vulnerable for a potential flood. The risk map indicates how high the water levels can rise and how many people and organisations are affected by a flooding. The three incident types are all represented in the risk map. The risk map is taking into account three flooding probabilities; a big flooding chance, a medium flooding chance and a small flooding chance scenario. Each scenario visualizes the impact of the flooding, the exposure and the vulnerability of a flooding on different sectors or living areas. The VRZ made a risk image of each individual municipality in the province of Zeeland. Those are in total 13 individual risks images (Veiligheidsregio Zeeland, 2015). The next paragraph is going into detail about the risk map of the municipality of Reimerswaal. The VRZ made a multi-disciplinary exercising plan what will be discussed in chapter 4.4.1 what goes in detail about the collaboration between the CI sectors and governmental institutions.

Next to the theme flooding crisis, the VRZ has also a theme considering failure of CI sectors. The electricity sector and drinking water sector are shortly mentioned and introduced. The two sectors are summarized and a map of its infrastructure is put into the crisis theme. The VRZ made a separate crisis plan considering the failure of CI sectors. The report covers all network owners in Zeeland, such as Enduris, Evides, Gasunie and Brabant Water. The report includes a large variety of scenarios concerning the above mentioned CI sectors. The scenarios consist out of a failure of two hours, two to eight hours, as well as eight hours or longer. The scenario charts are made for the electricity sector (Enduris), drink water sector (Evides and Brabant Water) and gas sector (Enduris). The scenarios explain what kind of consequences a scenario could have on society (Gisolf & Troost, 2016). However, a real life crisis event is never like a scenario, because a crisis event is always a bit different compared with a scenario (Troost, 2017).

Municipality of Reimerswaal

As mentioned in the previous paragraph, the VRZ made a risk chart of each individual municipality inside the province of Zeeland. The risk profile of the municipality is first mentioning the facts, like geography or demography of the municipality. After introducing of the standard facts, the VRZ is looking to every social theme. The crisis type flooding, extreme weather conditions and disruption of CI and services are the most relevant for this research.

The VRZ made a risk chart of the possible flooding's that can occur in the Reimerswaal area. The flood scenarios are divided into three occurrence chances; a high chance, a medium chance and a low chance (Risicokaart, 2016). The risk chart forms the basis of the crisis management plans in the municipality of Reimerswaal. The risks are visualized and the possible consequences are also included in the map. Together with the VRZ, the municipality of Reimerswaal is working on preserving and improving the aspects of flood safety. The municipality takes care of the direction and the mutual coordination of the plans. The integral safety policy leads to different projects that are implemented, like emergency responses. VRZ is making the crisis plans and the municipalities, like Reimerswaal, have to implement and coordinate the plans on local scale (Gemeente Reimerswaal, 2017).

The VRZ makes a regional risk plan and the municipalities like Reimerswaal, have to implement and coordinate the plans on local scale. The municipality of Reimerswaal assumes the CI sectors keep their crisis management plans up to date. The VRZ is a node when it comes to exchanging information about crisis planning (Huissen, 2017).

4.1.2. Flood risk management sector

The water board is a governmental institution with one important function: managing the quality and quantity of water within the region of influence. The water boards are therefore constantly busy with inspections and maintenance of the water system. The water board Scheldestromen is managing the water system in Zeeland and thus in the municipality of Reimerswaal (Waterschap Scheldestromen, 2016b).

The legal basis for drawing up a crisis plan and practising effective in the event of danger is laid down in the Water Act (Art. 5.29). In accordance with this article, the design of the crisis plan is geared to crisis management plans of importance for water management. The design of the crisis plan is therefore sent to the VRZ for comments. The plan is updated as often as necessary by the water board Scheldestromen (Waterschap Scheldestromen, 2016b).

The Scheldestromen water board has six separate crisis plans, however the plans taken in conjunction with the overall crisis plan of Scheldestromen. The overall crisis plan is the general crisis plan of the water board including the general crisis structure and measures during a crisis.

The other five crisis plans are so called partial plans. Only the first three partial plans are accessible. The other two partial plans are not accessible for the public. The partial plans include:

- Water barrier
- Surface water quantity
- Surface water quality
- Water purification
- Business continuity

The partial plan water barrier is focusing on maintaining the water barrier which is one of the key tasks of the water board. This partial plan is focusing on the primary barriers which keep the municipality of Reimerswaal protected from sea water. A map of the primary and regional water barriers can be found in appendix VI. This partial plan considers the following incident types:

Incident type
High sea water level
Damage through ship stranding's
Collapse of primary flood defence
Unexpected collapse of primary flood defence
Failure infrastructure in primary flood defence
Pollution on primary flood defence

Table 5: The incident types of the water barrier partial plan. Source: (Waterschap Scheldestromen, 2017a)

On the basis of the incident types, six normative scenarios are defined. The severity of a flooding can vary greatly from one event and is determined on the current occurring combination of factors; the nature of the incident, the location of the incident, the functions in the source area and the impact on the surroundings (Waterschap Scheldestromen, 2017a). The water surface quantity plan focusing on another key task of the Scheldestromen water board what is taking care of the water system.

This involves maintaining the correct level of surface water in the watercourses and steering structures. The water level in the watercourses should not increase too much from extreme precipitation otherwise the ground gets saturated and the water cannot be discharged anymore. The Scheldestromen water board made a scenario for extreme precipitation. In all scenarios it is necessary to visualize the effect area where the most vulnerable functions are protected. This can for

instance be an urban area or risky objects within the CI sectors (Waterschap Scheldestromen, 2016a).

According to Marco de Feiter, crisis coordinator at water board Scheldestromen, the following water infrastructures are critical for Scheldestromen:

- The primary and regional barriers; Prevent flooding from the sea or river
- The sewage infrastructure; Sanitation and water runoff
- The pumping stations; Keep the water level stable.

4.1.3. Drinking water sector

The drinking water company Evides is responsible to deliver drinking water in the municipality of Reimerswaal. Evides one of ten drinking water companies who are providing this basic need to society. The infrastructure of Evides Company is crossing the research area of Reimerswaal. Evides delivery area is included in appendix VII.

Since 2011, the national government of the Netherlands issues a new drink water law called the “Drinkwaterwet”. The recent drink water law issues that drinking water companies must deliver a decent quality of fresh water in all circumstances thus also in times of crisis. The law of 2011 also states that all ten drinking water companies in the Netherlands must develop measures to decrease the chance of both internal and external disruptions (Evides n.v., 2016a).

A company must develop a delivery plan based on disruption risk analyse. The outline of a delivery plan, such as for Evides, is shown in figure five. This includes how the legal obligations will be met in both the disturbed and undisturbed situations over the next ten years. The basis of this is the risk distortion analyse where this risks and included impacts are taken into account. The analyse takes around fifty different scenario’s into account, including a flooding scenario. The input of the Safety Regions is used from the regional risk profile for a flooding scenario. This is of course different per region, but the expertise of the Safety Region (including the VRZ) is taken over (Barm, 2017).

The risks are assessed in a multidisciplinary manner where all the parts of Evides are involved in assessing the impact that can be caused by an event scenario. The delivery plan must be approved by Inspectie Leefomgeving en Transport (ILT), the responsible ministry what supervises the drink water sector and drink water companies (Barm, 2017) .

If an event scenario happens, the drinking water companies are forced by law to deliver emergency drinking water to their customers. When the quality of the drinking water is not sufficient, it is called emergency water. This water may only be used for sanitation purposes in order not to endanger the citizens. The delivery security is in between the two phases, because drinking water must be available both in normal and crisis situations (Evides n.v., 2016a). Chapter 4.2.3 is going to have a closer look on the different crisis phases of Evides and provides a detailed explanation of the different phases.

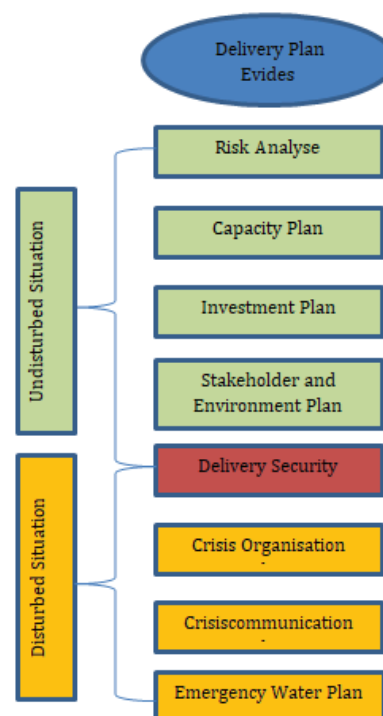


Figure 5: The Delivery Plan of Evides. Source: (Evides n.v., 2016a)

4.1.4. Electricity sector

Enduris is the owner of the regional electricity network in the province of Zeeland. The CI of Enduris is a vast network with more than 4000 km of medium voltage lines in Zeeland alone. The task of Enduris is to transport and distribute the electricity in Zeeland. Enduris has another approach considering risks compared with the other sectors, called asset management.

The asset management is a part of the organisational structure of Enduris. Asset management is managing the assets with the aim of creating value for the organisation. Asset management covers an entire life cycle of assets; from the selection to disposal and all the phases in between. A good management of assets is at the service of Enduris and its stakeholders. Although asset management does not look like crisis management, crisis management is included in the asset strategy of Enduris. The asset strategy of Enduris is focusing on six different aspects to ensure the quality of the services of Enduris. The six different assets are shown in table six.

Aspects of Enduris	Explanation
Safety	Contains frameworks where risks for own employees, third parties and environment are controlled
Quality	Contains frameworks for stability and reliability of services and products
Economy	Contains frameworks for the financial performance
Image	Contains frameworks for the desired image of Enduris
Stakeholders	Contains frameworks for the desired relationship with the stakeholders
Sustainable	Contains frameworks for resources and energy

Table 6: Aspects of Enduris' asset management. Source: (Enduris b.v., 2016b)

The aspect safety contains the framework where crisis management and risk reduction are discussed (Enduris b.v., 2016b).

A flooding scenario is included in the crisis management plans. However the chance that such a scenario happens is very small. Other risks are much more common like a digging incident where an electric cable is damaged, but Enduris is recently developing a better safety culture within the company where there is a better focus on identifying risks, also from possible flooding's. This mainly concerns the systematic application of management policies, procedures and practises to identify, analyse and evaluate the risks and to mitigate the measures. In order to realize the objectives the safety level, different plans are made with concrete programs, projects and activities.

The programs, projects and activities aim to get a better view of the risks inside the company, but also of risks in the surrounding environment. One project has the aim to identify and review the risks of the surrounding environment. This project include were the causes can be a natural disaster among other things like a flooding (Enduris b.v., 2017).

4.2. The crisis phases

This subchapter will explain how the crisis management phases represented in the different CI sectors and governmental institutions. The crisis phases consist out of pro-action, prevention, preparation, response and recovery. The pro-action, prevention and preparation measures are put together, because all the measures are taken before a crisis event making them comparable.

4.2.1. Governmental institutions

The emphasis of the VRZ is to prevent risks, but if the risks are escalating, limiting the risk as far as possible. The crisis circle of the VRZ is visualized in figure six.

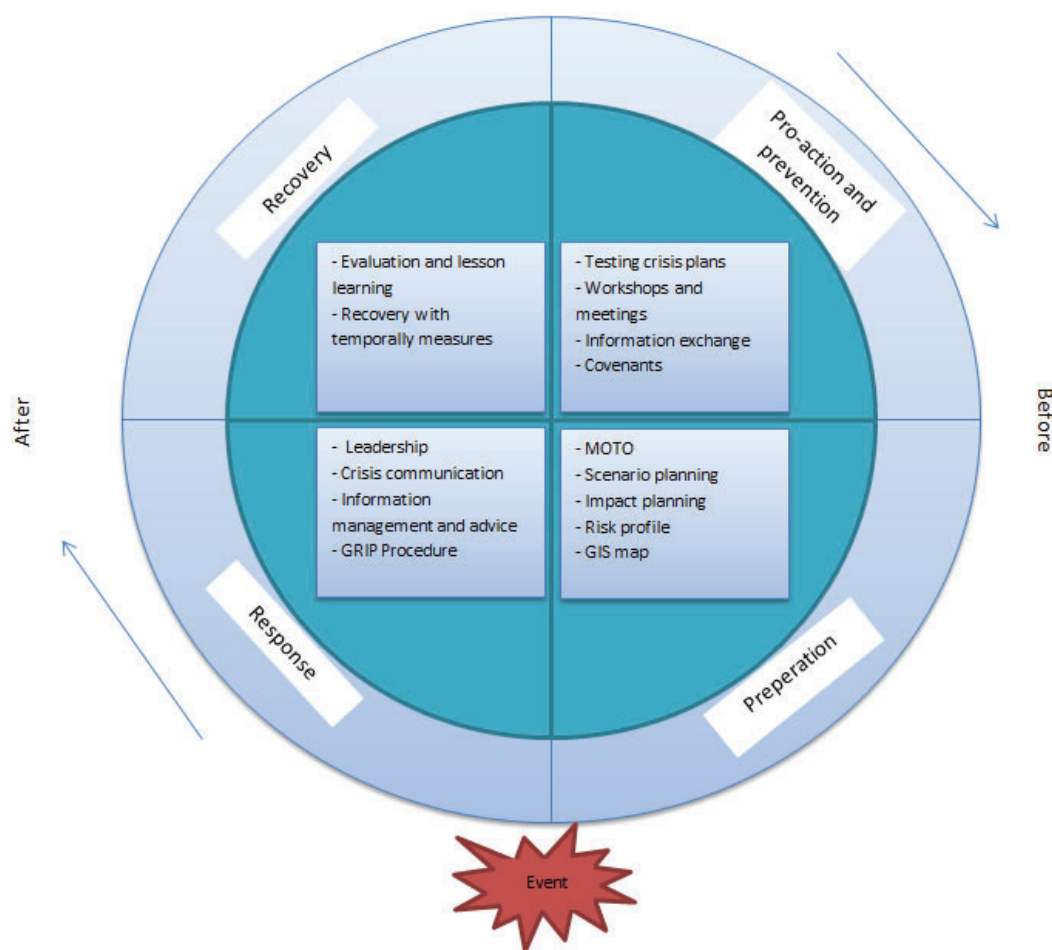


Figure 6: Crisis phases in the governmental institutions. (Source: Personal collection)

Pro-action, prevention and preparation

The VRZ makes a risk profile of the area what is covering all the possible risks that can occur in the area. The VRZ is taking into account all stakeholders regarding the physical safety of Zeeland. The risks are put into seven themes what is creating a risk profile of Zeeland and of each municipality. The VRZ is organising meetings with all the stakeholders in the Zeeland province to exchange data and to check their crisis plans. The risk plans are tested for usability, correctness and completeness. The VRZ aligns the plans with the CI sectors and test them for a certain period of time whether the plans are correct, complete and usable. If the plans are insufficient on these three criteria, the CI must adapt their plans according to the plans of the VRZ. The VRZ is also using the meetings in order to exchange information and data. The meetings have the intention to receive information from the CI sector, but also give new information.

The VRZ is actively collaborating in order to prepare and practise of a crisis event with the MOTO plan (multi-disciplinar opleiden, trainen en oefenen), but the collaboration will be explained in sub-chapter 4.4.1.

The VRZ made a large amount of covenants with different organisations and sectors. The covenants include agreements about risk prevention, crisis communication and leadership. The VRZ made a covenant with every major stakeholder in the province of Zeeland, such as Evides, Enduris, Pro-rail and Scheldestromen water board (Veiligheidsregio Zeeland, 2015).

Response

The basic requirements of the response phase of the VRZ are as followed:

- Alerting;
- Scaling up or down (GRIP);
- Leadership;
- Coordination and information management

Alarming aims to activate the units needed for emergency response and crisis management within a short time. All the emergency series must be alerted in order to respond to a crisis. After the alerting phase, the GRIP phase is put into action. The process involves activating the required people and resources and adjusting the way in which they are managed. The relevant partners of the VRZ are also warned about the emerging crisis. The GRIP procedure of the VRZ consists out of different teams which are deployed at different GRIP levels. The whole GRIP procedure can be found in appendix VIII.

The VRZ uses leadership is to manage the crisis organisation. It includes the actual deployment and control of the emergency assistance units. The leadership of the VRZ can be seen in the GRIP situation where different teams play a role in the crisis situation.

The next step is leadership and coordination. The goal of coordination is to manage the crisis organisation. It includes the deployment and control of the emergency assistance units. The crisis organisation starts with gathering information about crisis control and management. The information is analysed and assessed by experts. After the information assessing all possible actions are identified that can lead to the desired effect. Information management and coordination are closely linked with each other, because the right information is crucial during a crisis event (Veiligheidsregio Zeeland , 2011).

Recovery

In the recovery phase, the VRZ and its collaborating bodies are preparing measures to return to a normal situation as soon as possible after the crisis. The primary focus is the continuation of daily activities. The ROT (Regional Operation Team) of the VRZ identifies which facilities fail or need to be repaired and how long it will take to repair the facilities. The measures of different organisations are coordinated with each other. For example when Enduris is experiencing a power outage, the VRZ arranges emergency generators to ensure that daily life can continue. The emergency generators are put into place at essential facilities until the normal situation has returned (Troost, 2017).

The VRZ is evaluating the crisis in the recovery phase. The evaluation session is joined by the CI sectors to create a joint and uniform approach of learning. The lessons that are learnt are used to improve the crisis plans and can be used in crisis courses and workshops. In addition, the evaluations are used to develop better crisis exercises.

Municipality of Reimerswaal

The municipality of Reimerswaal is going through the same pro-action, prevention and preparation as the VRZ. The municipality gets its information primarily from the VRZ what acts as a source of information and planning.

The mayor of a municipality has the authority and supreme command in the event of a crisis in his or her municipality (until GRIP 3). The mayor is also included in the regional operation team (ROT) of the VRZ. However, if a disaster is more than local significance then the chairman of the VRZ is concerned with the crisis management in the municipalities (Veiligheidsregio Zeeland , 2011). The municipalities have an important role during crisis prevention and crisis management. This concerns tasks in the event of incidents relating to the population of the municipality. The tasks are:

- Providing information to the population;
- Providing shelter and care for the population;
- Taking care of aftercare for the population;
- Registering victims and;
- The registration of claims.

The tasks have been placed in an organisation called Population Care (Bevolkingszorg), a joint venture of the municipalities in Zeeland under the VRZ. The joint venture comes into action in the event of a crisis or in activities that are related to the preparation of a crisis. The municipality has the duty to inform its inhabitants. Emergency information is normally given via the regional broadcast, but when the electricity supply is disrupted the municipality gives instructions via a sound car from the police. The municipality can also set up an information point where citizens receive information about a crisis. The questions citizens have can be immediately answered by the municipality itself. In the recovery phase, the information about the end of the crisis can come from a CI sector itself and the municipality has to inform its citizens (Huissen, 2017).

4.2.2. Flood risk management sector

The emphasis of the water board is prevention. This is for example reflected in the safety standards of the primary and regional defense systems. The prevention of an occurrence of a flooding crisis is however not possible. The combination of the chance of occurrence and the consequences of the occurrence is the residual risk (Waterschap Scheldestromen, 2016c). The crisis phases of Scheldestromen are visualized in figure seven.

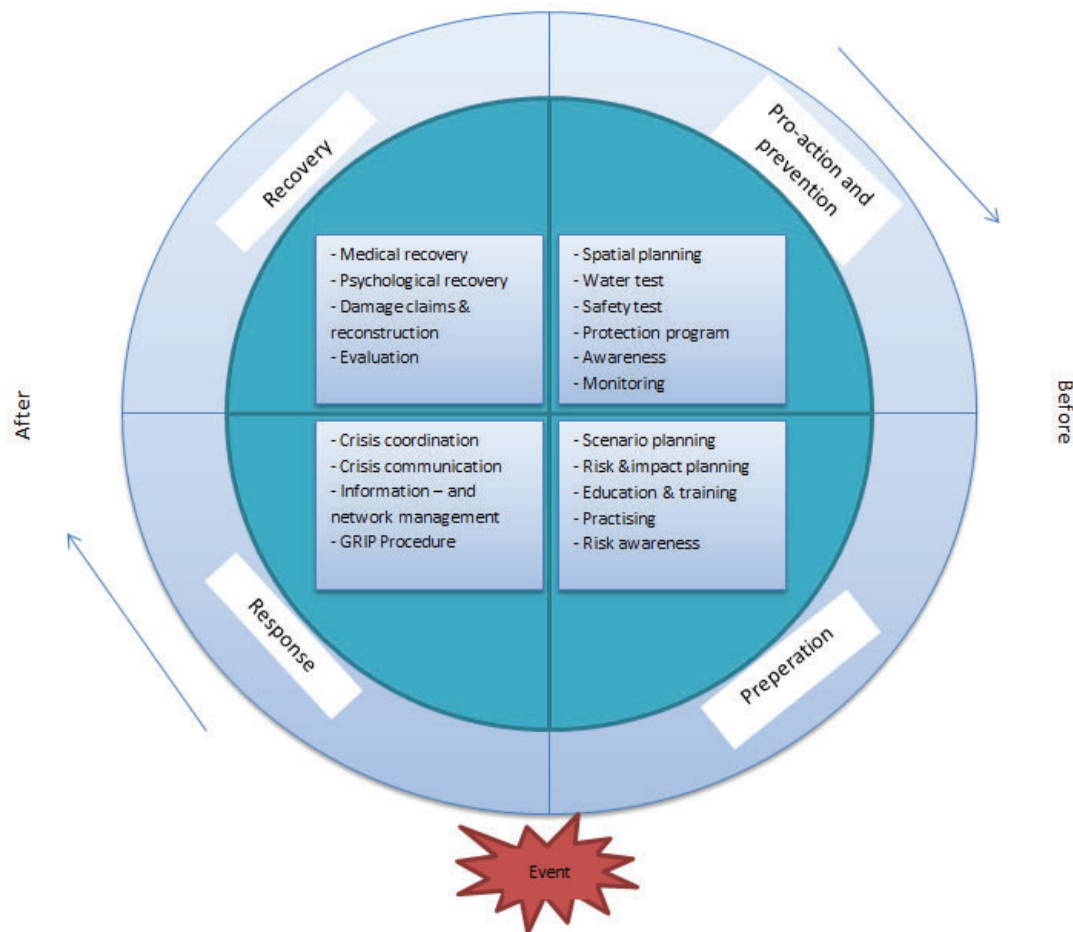


Figure 7: Crisis phases in the flood risk management sector. (Source: Personal collection)

Pro-action, prevention and preparation

Scheldestromen has wide spread measures on prevention, because the emphasis of the water board is the prevention of a flooding. Scheldestromen has a variety of testing measures. The water board has a lot of existing infrastructure which has to be maintained properly. Therefore, the water board is using test measures to test if a part of the infrastructure is still reliable and safe. This is done with the water test and a safety test.

The water test shows how well an area can collect and retain water, for instance in a low lying polder. The area is tested how fast the area is flooded and how much water the area can hold. This is important, because heavy downpours contain a lot of water and Scheldestromen.

A safety test checks the water stress on a specific structure, such as a dike or barrier. The barrier is tested if it is holding against a specific water pressure or weather condition. Every barrier is tested every six years to guarantee its safety. When a barrier is not sufficient enough compared to the standards, it needs to be improved in order to meet the quote of the standard (Waterschap Scheldestromen, 2016c). In addition, the safety standards of the primary barriers adjusted by the protection program of the Delta Commission. The new safety standards are up to date with the most

recent climate models to ensure maximum protection. Since 2017, there is a different safety standard system. The new system implies that not all flood defences have the same safety standard, but a different safety standard per dike section. The standard is calculated by looking what the economic value is behind the dike section and how many people are living behind the dike section (Waterschap Scheldestromen, 2017a).

Water board Scheldestromen is also making use of spatial planning. When a new implementation or measure is constructed, things like environment or economy are taken into account to prevent damage and optimize the use of the new implementation. An example of this is the testing of new and innovative poles for bank protection. The poles are made from bio based materials making the protection more sustainable and cause less harm to nature (Waterschap Scheldestromen, 2017b).

Response

Scheldestromen is modified to adapt when a crisis situation is evolving. The crisis organisation is scaling up when a crisis is escalating. This means that the organisation puts in more resources and equipment to handle the crisis. The coordination phases are in line with the national GRIP procedure. The GRIP procedure of Scheldestromen water board can be found in appendix VIII.

Scheldestromen has flexible crisis coordination where communication is an essential part. The crisis organisation of Scheldestromen is build-up of multiple teams. This is keeping the crisis coordination of Scheldestromen flexible due to three levels; strategic level (Policy team), tactical level (Operational team) and operational level (Action team). The three levels are tuned with each other to reach maximum coordination in times of a crisis. The tactical and operational teams are working together. A communication team exists between those two teams. The team is coordinating the communication between the operation and policy team and makes sure that both teams are getting the same information.

A crisis is contested by multiple organisations. Scheldestromen made agreements with RWS, Zeeland province, the 13 municipalities in Zeeland and with the VRZ. The agreements ensure a better and smoother collaboration between partners in times of a crisis. The agreements include the exchange of information and agreements on the task division of organisations during a crisis. The availability of information is essential during a crisis. It is important that the teams get the right information on the right time. All employees need to understand the importance of information during a crisis, also the information from external parties (Waterschap Scheldestromen, 2016b). (Ministerie van Infrastructuur en Milieu en Ministerie van Economische Zaken, 2015)

Recovery.

The primary focus of the Scheldestromen water board is to reconstruct or repair damaged CI as quickly as possible. The reconstruction work is explained per different scenario in the scenario planning of the water board. For example, the scenario high water from the North Sea. There will be damage to the dunes and various places at the primary barriers, because dike covering pieces will be heavily damaged. The repairs will be done as quickly as possible by the Scheldestromen water board to prevent further escalation. If the primary barrier has collapsed, the water board uses extra measures to absorb the wave billow and use extra deposits of stone to prevent more damage. The water board can use emergency pumps when the water level is extremely high caused by extreme precipitation. The emergency pumps drain the water out of the affected region to specially assigned water buffer areas or to a pumping station what is transporting the water into the sea. When the situation is back under control, Scheldestromen will start with reconstructing the damaged infrastructure (Waterschap Scheldestromen, 2016a).

A part of the recovery phase is physical recovery for the staff. The physical recovery includes physical help for the staff and adapted working hours so that the staff can recover better from the crisis.

Another part of the recovery phase is the evaluation of the crisis. After the complete downscaling of the GRIP, the crisis coordinator is assessing the crisis. The evaluation has three specific goals:

- Learning from lessons and experiences that the crisis organisation has gained;
- Accountability to policy field managers and administrations about the crisis approach, developed resources and the crisis management process;
- The Water Act states that the administration is responsible for an evaluation of the action and further actions in events of danger (Waterschap Scheldestromen, 2016b).

4.2.3. Drinking water sector

The emphasis of Evides is to deliver drinking water in every situation, disturbed or undisturbed. The delivery security is thus of great importance. The crisis phases of Evides are visualized in figure eight.

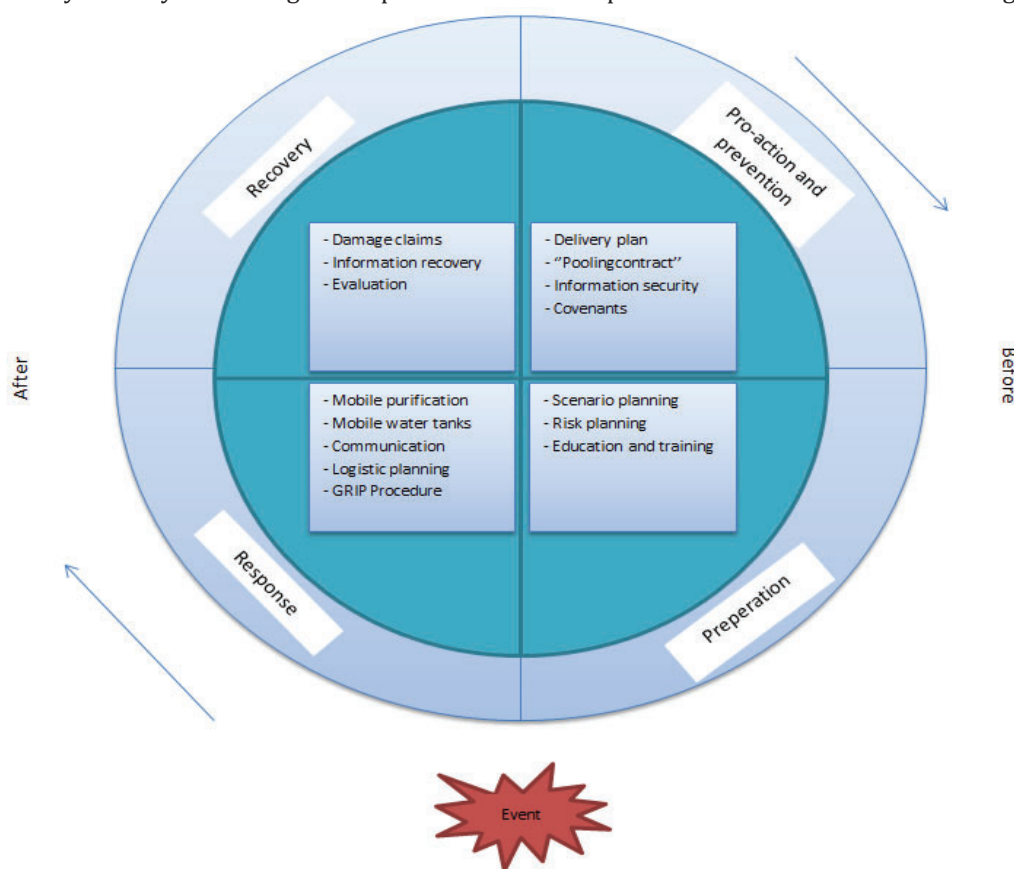


Figure 8: Crisis phases in the drinking water sector. (Source: Personal collection)

Pro-action, prevention and preparation

As mentioned in the previous paragraph, Evides is legally forced to make a delivery plan. This includes how the legal obligations will be met in both the disturbed and undisturbed situations over the next ten years. The basis of this is the risk distortion analyse where this risks and included impacts are taken into account. The analyse takes into account around fifty different scenario's, including a flooding scenario. Evides also made a "poolingcontract" with all Dutch water companies. The contract states agreements of commitment when a drinking water company needs material and manpower for emergency drinking water. This means that drinking water companies made agreements to help each other in dire situations (Evides n.v., 2016a).

Evides has made covenants, simplified agreements, with the five safety regions (Zeeland, Rotterdam-Rijnmond, Midden- en West-Brabant, Haaglanden and Zuid-Holland) in its delivery area in 2010. Evides made thus multiple covenants with VRZ. Evides has made a separate covenant with the VRZ,

Police Zeeland and Brabant Water. This covenant is about cooperation between the partners related to risk and crisis management in the Zeeland region. The goal of the covenant is, considering the mentioned parties, to increase the knowledge of each other organisations and processes. The covenant focuses on good risk and crisis communication, effective cooperation and incident management and security. The covenant states:

- Risk management; Evides is responsible for information and communication towards its customers with regard to risk prevention measures;
- Crisis communication; parties make agreements in the preparation phase about crisis communication related to drinking water incidents;
- Leadership; parties actively inform each other about changes and existing plans with regard to risk and crisis management;
- Practising and exercising (Veiligheidsregio Zeeland, 2008).

Evides shares as much information as possible to other parties. However, Evides is doing this with care, because certain information is sensitive to share. Evides is sharing information only where Evides has benefits from, for instance the police and fire brigade to maintain security at Evides' infrastructural strong points. This can be seen as information security. Evides is sharing not every piece of data with others. This is because the vulnerability of the drinking water infrastructure and not to make it even more vulnerable (Barm, 2017).

Response.

When the infrastructure of Evides is failing, additional measures must be implemented to deliver water to the disturbed area. When, for whatever, reason the regular drinking water supply is expected to be out of service for a period longer than of 24 hours and affects more than 1.000 citizens, Evides must enable their emergency plans.

When the drink water supply fails, Evides can deliver around the network by using mobile or flexible water tanks. The water is in large water sacks which are delivered by trucks. One water sack contains 10m³ of drinking water. The truck is driving to a distribution point in the affected area. Every person is getting three litres of water, two litres for drinking and one litre for sanitary purposes. One distribution point provides water for 2500 persons. The amount of distribution points depends on the amount of people living in the municipality. There are nine distribution points in the municipality of Reimerswaal. Due to the delivery trucks, the system of distribution is flexible. Beforehand, the most favourable locations are chosen; however, the flexible water delivery can set up a distribution point on another place where the water is most needed.

The population needs to know what to do when the water provision fails and where to get the emergency water. The message can be external communicated through social media, the website of Evides, NL-alert or the regional broadcast (Omroep Zeeland). The regional news broadcast announces where and when to come to the distribution points to receive emergency drinking water. Even if the telecommunication infrastructure is out of service, the population gets informed with a sound car or truck. Evides can even invoke the military. The military (Koninklijke Landmacht) has mobile purification plant at its disposal. The purification plants can purify the water in such a condition that it can be used as emergency water, but not for drinking water due to the high standards for drinking water (Evides n.v., 2016b).

Recovery

When the disruptive situation returned to a normal again the emergency circumstance is over. Evides is sitting together with the regional parties and is informing the parties in a meeting. The meeting puts an end to the emergency situation and requests the municipality to inform its citizens about the

normal situation. Evides will inform their most important customers themselves about the end of the emergency situation while the citizens are informed by the municipality or by the regional broadcast. The people, who received extensive damage of certain water damage, can request a damage claim. This is for instance when the water damage is caused by a burst in a water pipe (Evides n.v., 2016b). In 2009, Evides paid 150.000 euro to victims of a water pipe leak (Reformatisch Dagblad, 2009). Evides has also an evaluation phase during the recovery. This evaluation is done together with the inflicted municipalities and emergency assistances. The evaluations are used to develop new measures to prevent a similar scenario in the future (Evides n.v., 2016a).

4.2.4. Electricity sector

The emphasis of Enduris is asset management what covers the assets of the services of Enduris and its stakeholders. Crisis management and risk analyses are included in the asset strategy of Enduris. Figure nine below shows the crisis phases of Enduris.

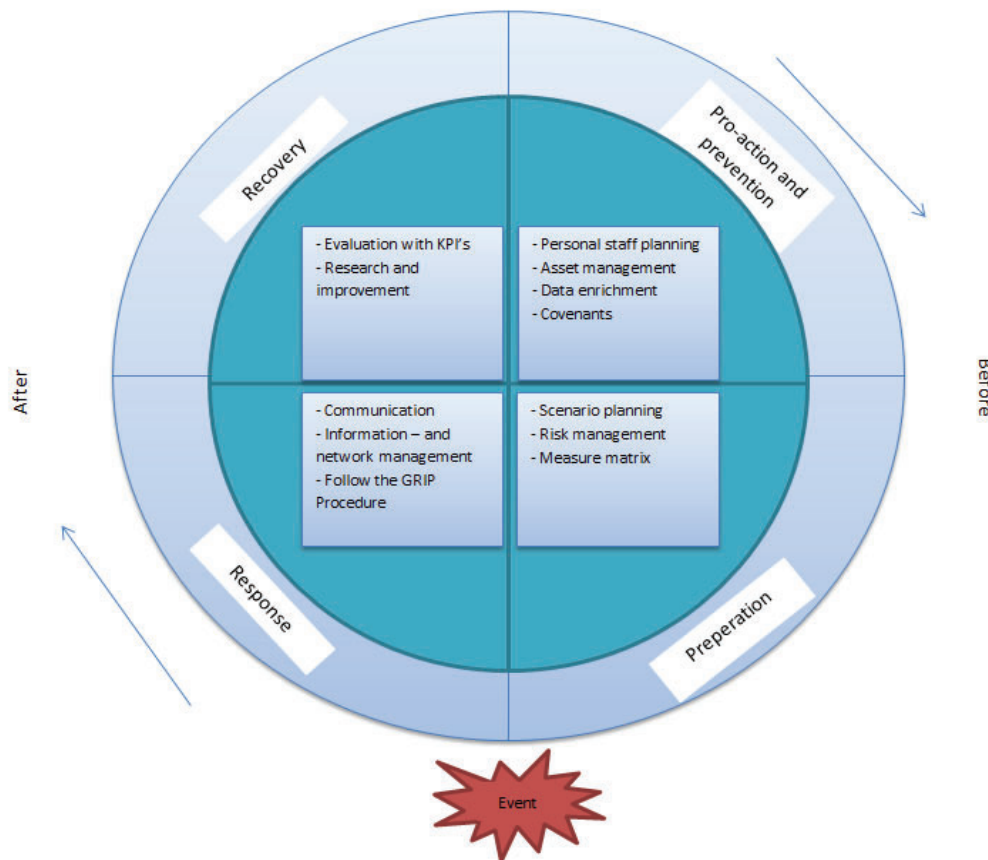


Figure 9: Crisis phases in the electricity sector. (Source: Personal collection)

Pro-action, prevention and preparation.

The importance of data is crucial in order for crisis preparation. The expansion of the data base and the demand for specified information is increasing. Moreover, more documents and details are included in the data base thus increasing the importance of an integrated database. Enduris makes a capacity plan every year which includes the development and planning of the organisation. The capacity plan also considers a long term vision. This vision of the future is a vision of maximum ten years and this long term vision is revised every two years. The capacity plan also revises the possible risks with risk management. The risk management of Enduris is a continuing process to picture risks and prepare measures against those risks. The risks management cycle inside Enduris consist out of six phases and is presented in figure ten.

The outcome of the risk management process is the risk matrix. The risks are ranked on safety, quality, environmental- and economical damage. The risk matrix is visualizing the risks but is also a tool to develop measures against the risks.

Enduris is also conducting location visits at various locations of their network. Enduris is doing the location visits in order to calculate the possible height of the water level compared with the height of the electricity wires. Hereby, Enduris can calculate at which water level a certain electricity infrastructure part can fail. However, Enduris has a vast electricity infrastructure. Enduris has 3500 medium voltage switch stations in Zeeland alone.



Figure 10: The risk management line of Enduris. Source: (Enduris b.v., 2016b)

Like Evides, Enduris has also made a covenant with the VRZ, police force of Zeeland and the electricity managers in Zeeland (Enduris and TenneT). TenneT manages all the high-voltage lines in the Netherlands and in parts of Germany. The covenant focuses on good risk and crisis communication, effective cooperation and incident management and security. The covenant states:

- Risk management; the parties look together to the risk in the province related to electricity. The VRZ processes this in the regional risk profile.
- Crisis communication; the mayor ensures that the population is provided with information about the origin, extent and consequences of the crisis. The VRZ plays a supporting role in this situation. If the public administration is not informed yet, the network owner who is involved ensures for the crisis communication.
- Leadership; parties actively inform each other about changes and existing plans with regard to risk and crisis management (Veiligheidsregio Zeeland, 2012).

Enduris made a measure matrix as well. The matrix includes four different phases (normal threat, light threat, moderate threat and high threat) and each phase includes different crisis measures, personal measures and information measures. The measure matrix of Enduris is shown in appendix IX. The measure matrix clarifies exactly how measures are implemented at each phase of a crisis phase or crisis situation.

Response

The emphasis of Enduris during the response phase is to bring back the normal situation as quickly as possible. This means that the power outage should be quickly resolved. As mentioned in the previous paragraph, Enduris is not responsible to deliver emergency aggregates to other organisations (except the regional broadcast) which mean Enduris can fully focus on solving the power outage. During the period of power loss, Enduris is communicating directly with the VRZ about the crisis. This emergency line is between the headquarters of Enduris and the headquarters of the VRZ. Enduris is following the GRIP procedure of the government. When the GRIP is scaling up, Enduris is increasing the amount manpower and equipment to resolve the crisis situation. The measure matrix shows how Enduris is following the GRIP. Enduris has his headquarter in Middelburg and a second location in Goes. The crisis team can be moved to Goes in case that something is happening in Middleburg. In the event of a flooding in both facilities, which would be the worst case scenario, Enduris has a flexible option. They can call their mechanics and give instructions and assignments via the mobile phone.

Enduris made a binding agreement with the regional broadcast, Omroep Zeeland. If there is a power

outage, Enduris will arrange an emergency aggregate for the broadcast. Enduris made only a binding agreement with the regional broadcast, but not with other organisations. Enduris included a list in their crisis plan of companies who rent out an aggregate. The other organisations are responsible for their own emergency aggregate.

Recovery

Enduris is constantly busy with conducting research towards disruptions, incidents or accidents. This is part of the asset management of Enduris. The aim of this process is to identify the underlying defects which can cause disruptions. Enduris determines the risk level of corresponding defect and what kind of impacts it has on safety, quality and capacity. Enduris is utilizing the results and publish the results of the research.

The evaluations are made from continuous researching by Enduris and evaluations are made after a disruption in their system. The evaluation reports are given to the management including the learning points. The learning points are included in the capacity plan to prevent new disruptions from happening.

4.3. Cascading effects

This subchapter will analyse how the mentioned governmental institutions and CI sectors are incorporating cascading effects into their crisis planning.

4.3.1. Governmental institutions

Veiligheidsregio Zeeland

The national government of the Netherlands developed a guide for impact analyses and evacuation for the Veiligheidsregios. The guide focuses partly focuses on CI and how the CI sectors are interconnected with each other. In addition, the guide shows which institution or sector is responsible for the delivery of information. The guide states that the Veiligheidsregios need to map the CI and critical objects in their regions. Moreover, the guide states that this information needs to be shared with all relevant stakeholders within the region (Insituut Fysieke Veiligheid, 2017).

As mentioned before, the VRZ creates a risk chart where all relevant stakeholders and their interests are taken into account. The map results in a clear overview of the different CI sectors and their networks. The VRZ is receiving information and data from the CI sectors in meetings, but the VRZ expects that other CI sectors are sharing their information willingly with the VRZ. This is known as bringing and giving information. The information and data which is shared also contains Geographic Information (GIS) data. The GIS data can be implemented in a large GIS map with all the data from all relevant stakeholders and infrastructures. The GIS data in combination with different flooding scenarios can show what part of the infrastructure is struck by a flooding. However, some of the data which is sent to the VRZ is old data. The old data or incomplete data reduces the quality of the information map as well as the estimation of risks or cascading effects (Troost, 2017).

Municipality of Reimerswaal

The municipality of Reimerswaal gets the regional risk profile from the VRZ. The municipality gets the same information like the VRZ. The GIS data and the GIS map of the VRZ are accessible for the municipality. The municipality of Reimerswaal expects that the CI sectors their data and information in the GIS map as much as possible.

The municipality is part of the consortium and participated in the Circle method workshop on the 21st of September. Wim Huissen, advisor public safety of Reimerswaal, attended the workshop and says: “the tool is very interesting and useful, but it is still abstract. I am looking forward to see the cascade effects and interdependencies in the next workshop”.

The municipality would like to know more about the cascading effects of CI sectors in order to improve the crisis preparation and response measures in the municipality of Reimerswaal (Huissen, 2017).

4.3.2. Flood risk management sector

The Scheldestromen water board is making a risk matrix to identify possible impacts of a certain risk. In the background of the matrix, cascading effects are taken into account. Scheldestromen is looking at other CI sectors; however this is limited which means that not everything can be included. The limitation is caused by the limitation of data given to Scheldestromen. As mentioned in 4.1.2, the severity of a flooding can vary greatly from one event and is determined on the current occurring combination of factors; the nature of the incident, the location of the incident, the functions in the source area and the impact on the surroundings. The water boards have to include possible impacts on other CI sectors in the region caused by a possible flooding (Waterschap Scheldestromen, 2017a).

Scheldestromen is also analysing the possible cascading effects on their own CI, for instance the electricity wires at a pumping station. Most of the pumping stations are below sea level and Scheldestromen is analysing where the electricity wires are located and how high the water level needs to come to cause a short circuit. Scheldestromen is looking at how the pumps are functioning at a water level of two to three meters. If the water is reaching the electrical wires, the wires must be redesigned to prevent a cascading effect during a flooding. This research is recently been started and the results should be known in 2018. If CI of the water board is affected by a power outage, for instance an open sluice, the water board sends mechanics to the designated place to close or open the sluice and prevent a chance of flooding. When a water pumping station is affected by a flooding and is out of service, the water can be redirected to another water pumping station in the area (Feiter, Interview Waterschap Scheldestromen, 2017).

4.3.3. Drinking water sector

Evides is well aware that their drinking water infrastructure is dependent on electricity. When the electricity network is failing, the drinking water production and supply is out of service. Drink Article 50 states that all drinking water companies including Evides must be self-sufficient for ten days after a power outage. The marge of ten days has been chosen, because this is the average time of a power outage in the Netherlands. Evides has emergency generators (running on diesel) at every important location concerning the drinking water supply. Hereby, Evides can be self-sufficient for an average time of ten days as long as the diesel stock lasts (Evides n.v., 2016b). However, Evides expects to be able to supply drinking water via emergency power for more than ten days. This is because the demand for water declines when there is a power outage. This happens because consumers might not able to use hot water or the production of companies is slowing down (Barm, 2017).

If the average time of ten days exceeds, Evides respond with an emergency water procedure. Lydia Barm, strategic advisor of Evides, suspects that it is more effective and efficient for the production of drinking water and supply than to supply emergency drinking water using trucks. The trucks need diesel for transportation. Evides argues for diesel delivery to the vital sectors in the event of a disruptive scenario, like a flooding, when the power outage has not been restored within ten days. The central government (het Rijk) has to prioritize this (Barm, 2017).

Evides uses a joint tool with the entire drinking water sector. The tool has been drawn up for the disruption risk analyse considering cascading effects as well. The ministry of ILT keeps an overview over the tool (Barm, 2017).

4.3.4. Electricity sector

Enduris is well aware that almost every sector and organisation is heavily depending on electricity. The first priority of Enduris during a disruptive event is to fix the power outage as quickly as possible. As mentioned in the previous paragraph, Enduris is conducting research on their infrastructure in the delivery area (including Reimerswaal). Enduris is doing location visits to the infrastructure network in the delivery area. The researchers are calculating the possible height of water level and comparing the water level with the height of the electricity wires. The researchers can calculate at what water level a certain part of infrastructure is experiencing a short circuit. The findings are put into a GIS map where Enduris can see the height of the critical infrastructure. Enduris is making use of their own manpower and knowledge rather than relying on an external company or organisation who is researching this subject. Thanks to the research, Enduris knows where their infrastructure is vulnerable; however the CI of Enduris is vast what means it takes a lot of time to research their entire infrastructure network. However, the research does not show how cascading effects can impact the infrastructure of Enduris or CI of other organisations, but the data is of great importance to visualize cascading effects.

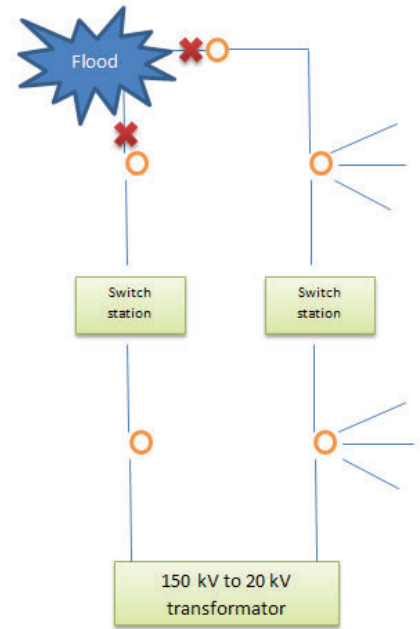


Figure 11: Scheme of an electricity net shutdown.
Source: (Zweemer, Minderhoud, & de Neijs, 2017)

Enduris can limit the impact of a power outage by making smart use of switching stations (represented in figure eleven). When a part of the electricity infrastructure is flooded, Enduris can switch off stations in order to limit the impact of a disruption. When a flood impacts a part of the electricity infrastructure, the whole system can shut down due to a short circuit. Nonetheless, Enduris can limit the impact by smart usage of its infrastructure. Enduris sends employees to the electricity houses (orange) to disconnect the flooded part of the infrastructure from the network as long as it is flooded. The other part of the infrastructure can function normally and the customers of Enduris are getting electricity. The switch stations and the transformer houses are equipped with an emergency generator as a backup in case the electricity in the houses should fail. In the meantime, an employee of Enduris can go the house and repair the damaged infrastructure (Zweemer, Minderhoud, & de Neijs, 2017).

4.4. Collaboration, exercising and practising

This chapter will analyse the ways the governmental institutions and CI sectors are collaborating with each other, such as exercising and practising.

4.4.1. Governmental institutions

Veiligheidsregio Zeeland

The VRZ has a multi-disciplinary exercise policy plan that combines the vision and ambition and looks at its professional competence from an educational and innovative perspective. The safety regions are legally obliged to develop a multidisciplinary training and practice plan (MOTO) at least once every four years. The MOTO is prescribed in the Act of the Safety Regions and is important to organisations and teams in the Safety Region to prepare for a crisis. The MOTO is in line with the regional risk profile and is updated once every four years such as the regional risk profile. The MOTO describes the legal and administrative obligations of the VRZ and is partly developed by interviews with responsible persons within the VRZ. The MOTO is legally required but also necessary based on professionalism to ensure an optimal level of safety.

As stated before, a MOTO plan must be developed at least once every four years. VRZ made a MOTO plan for the period 2015-2018. The VRZ made a survey which shows that “practise to practise” is not effective. MOTO is more focused on small scale practise moments in the 2015-2018 periods. Practise in the coming policy period is mainly focused on forming a measuring moment, helping to give learning moments. The annual policy of the MOTO is worked out and put in an annual year calendar. The annual plan includes an overview of educating, training and practising and its objectives. The plan has to pay attention to all parts of the MOTO. (Veiligheidsregio Zeeland, 2014).

The VRZ organises special network and theme days to encourage collaboration. The day is organised for individual citizens, interest groups, emergency groups, governments, businesses and educational institutions. All these partners have an interest as well as a responsibility for a safe and resilient society. The theme days have different subjects, such as crisis planning, road infrastructure or failure of utilities (Veiligheidsregio Zeeland, 2017b).

Patrice Troost mentioned that there is a system test of the VRZ structure from top to bottom once a year. The system test is a legally obligated test. The exercise is intended for all parts of the main structure of the VRZ. The exercise tests and checks if the main structure of the VRZ meets the basic requirements during a crisis situation. Attention is paid to alarming, GRIP, information provision and crisis communication. The exercise is a GRIP 4 situation scenario and the exercise consists of a chosen scenario and the experts within the VRZ have to solve the given crisis scenario. The experiences during the exercise can be used as reflection points on what went right and what went wrong. In this way, the VRZ is learning from its excises (Troost, 2017).

Municipality of Reimerswaal

The VRZ is working close together with the 13 municipalities in the province of Zeeland. Since 2014, the new standard of the VRZ is to do a policy team exercise (BT-oefening) with every municipality once a year. The exercise is performed on the basis of a scenario. The scenario is a realistic and recognizable crisis situation. The exercise tests the participants and their experiences of the Reimerswaal policy team. The municipality of Reimerswaal is also involved in workshops of the VRZ where information and new learning lessons of safety are shared and discussed (Veiligheidsregio Zeeland, 2014).

The municipality of Reimerswaal is practising with Evides and Scheldestromen as well. The exercises with the two CI sectors are at least once every two years. Evides is testing the flexible water sacks and the distribution points and Scheldestromen, for instance the sewage system in Kapelle (Huissen, 2017).

4.4.2. Flood risk management sector

The Scheldestromen water board has an integral crisis management system. The system is the overall unit that ensures the continuity of the crisis organisation and is embedded in the organisational structure of the water board. The different parts of the system are training, educating and practising. Practising with the crisis plans is necessary in preparation for a crisis. Yet practise is not a self-standing goal, it must be part of a series of activities. The personnel of Scheldestromen have to be trained in dealing with crisis and the crisis plan must be regularly practised with the involved parties.

Once every four year, a multi-year policy plan (OTO-Beleidsplan) is drawn up in accordance with the multi-annual policy plan format. The multi-year policy plan describes the way in which the organisation prepares for crisis in the next four years by means of training, education and practising.

On the basis of this policy plan, the definitive annual program is completed and implemented every year. The annual plans in turn form the basis for the elaboration of the proposed activities.

Exercises vary in size and type. In the first instance, small-scale training is practiced; gradually more areas of attention are practiced. First a number of exercises are organized in which parts of the plans are tested; for example the effectiveness of the connection system.

The following are more extensive exercises, including such a situation that the functioning of the management of the crisis organisation and all the officials involved are tested. Municipalities, provinces and anti-trust organisations are involved in this. Consultations on this kind of large-scale exercises take place through the safety region (VRZ). On the basis of the notes made during the exercises and the first evaluation, a written evaluation with adjustment proposals for the crisis plan is elaborated (Waterschap Scheldestromen, 2016b).

Water board Scheldestromen has an excellent relationship with the regional governments and the VRZ concerning collaboration. Scheldestromen is sharing as much information as possible about their crisis plans and their CI networks. However, crisis coordinator Marco de Feiter finds it sometimes difficult, that other sectors do not share their information concerning CI, while the information is important to know, but he respects the choice (Feiter, Interview Waterschap Scheldestromen, 2017).

4.4.3. Drinking water sector

The Drink Water Act contains an obligation for all drinking water companies to at least practise in a multidisciplinary manner once every two years. The security and crisis coordinator of Evides is responsible for the organisation of training and exercises. Evides strives to conduct an exercise at least twice a year that includes a part of the crisis management procedures. Evides is therefore participating in relevant operational crisis exercises, the multi-disciplinary exercises, in the delivery area of Evides (Evides n.v., 2016a).

Evides is making an exercise schedule every year, just like the VRZ. The exercise schedule includes practise schedules with a variety of sectors. Evides is exercising with KPN (Dutch telephone company), ICT companies or with nuclear power plants in Borsele and Doel (Belgium). Often there are even more exercises stated in the yearly schedule plan. The exercises keep the relations and interests between other sectors and Evides at a decent level. Moreover, the exercises keep the crisis management plans at Evides up to date and good cooperation during crisis situations is essential. Therefore Evides is cooperating with ILT, the municipalities, the emergency services and the military. Evides is therefore participating in multidisciplinary exercises with the relevant stakeholders in the delivery area of Evides (Evides n.v., 2016b).

Evides regularly organizes a mini symposium for all members of their crisis management organisation. Other sectors, like water boards or the electricity sector, are invited to speak about their crisis organisation and recent developments. The goal is to learn from each other and to be updated in the last developments of each other. Evides is also meeting up with the other drinking water companies in the Netherlands to discuss developments in the drinking water sector (Barm, 2017).

4.4.4. Electricity sector

Despite the fact that crisis in the electricity supply are quite rare, it is important that Enduris is prepared for a crisis. Enduris has up to date emergency plans and exercises are organized annually

in which crisis scenarios are simulated. Enduris is practising the crisis scenario in a simulation room in order to improve the preventive measures of their crisis management (Enduris b.v., 2016a).

The emergency plan of Enduris is periodically practised, including with the VRZ. An exercise took place in December 2015 with the aim of training the Enduris policy team in dealing with an external crisis situation that could arise during a flooding in a part of Zeeland. The effects that a flood can have on the electricity infrastructure are very educational to experience (Enduris b.v., 2017). Once a year, Enduris is exercising with the VRZ. It also comprised out of exercising the crisis emergency line between the VRZ and Enduris. The exercise consists of how the two parties communicate towards each other in a crisis scenario. The crisis line is checked multiple times a year (Zweemer, Minderhoud, & de Neijs, 2017).

Enduris participated in the Circle workshop of the Resilient Deltas research group on the 21st of September. Enduris actively shared information about their electricity and gas infrastructure in Reimerswaal. The responsible person of Enduris (Wim Zweemer) actively debated and pointed to errors on the infrastructure map of the research group.

Since 2015, Enduris and TenneT join forces in TeslaN. TeslaN is a strategic cooperation in the field of management and failure of high-voltage installations in Zeeland between Enduris and TenneT. This joint approach focuses on total unburdening in the management, maintenance and failure of high-voltage and medium voltage in Zeeland. TeslaN places the safety of its people and environment at the first place (Enduris, 2015).



Figure 12: Wim Zweemer (left) actively shares information about Enduris. (Photo taken by J.M. Buijs)

4.5 Analysis of the results

This subchapter explains the most important results and discuss what the results mean. This subchapter is subdivided according to the sequence of the sub questions.

4.5.1. Crisis management plans

The first paragraph analyses the crisis management plans in case of a flooding scenario in relation to the contribution to resilience.

The VRZ develops a regional risk profile of the province of Zeeland. This profile includes all relevant partners and stakeholders within the province of Zeeland. The VRZ develops an incident map where all vulnerable objects and locations are put into. The stakeholders give the information of their vulnerable objects and locations what creates a risk map of all the risks that can occur in Zeeland and its municipalities. This contributes to the resilience, because all the key stakeholders and their important assets and infrastructures are incorporated in the regional risk profile. The VRZ identifies the key risks with the help of the risk map. The risk map is able to indicate how high the water levels can rise and how many people and organisations are affected by a type of flooding. The risk map creates a summary of all risks including what type of crisis scenarios can happen within the VRZ. The set of skills and knowledge help prepare the VRZ for a disruptive crisis event. This makes the VRZ ready to resist, react and recover such an event.

The VRZ made a separate risk image of the municipality of Reimerswaal. The municipality is working

together with the VRZ to preserve and improve the aspects of flood safety. This contributes to the resilience, because the local expertise is used from the municipality while the flood crisis expertise of the VRZ is used to check the crisis plans of the municipality.

Scheldestromen developed six separate partial crisis plans and an overall crisis plan for the organisation. The partial plans focus on one specific task of the water board for instance flood risk management. The partial plans consists out of multiple risk scenarios what explain a possible scenario and what kind of measures need to be taken to minimize such crisis situation. The partial plans include the key functions within the organisation of Scheldestromen and identify the key risks scenarios using scenario planning. Scheldestromen becomes more resilient, because the organisation has different partial plans for every key function within the organisation. Moreover, the partial plans consist out of multiple incident scenarios as stated in table five. The set of skills and knowledge about their functions and operations help Scheldestromen to prepare for a crisis and make to the organisation ready to resist and react to a risk scenario.

Evides developed a delivery plan. The delivery plan consists out of different analyses to identify the stakeholders and risks inside the delivery area of Evides. The risks inside the delivery plan are based on a risk analyse, where the risks are estimated and put into scenarios. The analyse takes around fifty scenarios into account including a flooding scenario. The risks are assessed in a multi-disciplinary way what means that different parts of the organisation look to the risk analyse. The process of making a delivery plan includes all the key functions in the organisation within Evides. The stakeholders and the key risk scenarios are identified. The resilience of Evides is enlarged, because the delivery plan helps Evides to prepare for a crisis and makes the organisation ready to react to a disruptive event. Moreover, the delivery plan is assessed in a multi-disciplinary way so that every layer of the organisation knows what to expect and what to do in case something happens.

Enduris uses asset management what consist out of multiple aspects. One aspect is safety. It contains crisis management and risk reduction. The aspect of safety also contains a flooding scenario; however the focus lies more on other risks like a digging incident, because such risks are happening more often. Enduris is developing concrete programs, projects and activities to identify risks better also for a flooding risk scenario. This makes Enduris more resilient in the future, because it makes the organisation better prepared against other types of risks, for instance a flooding scenario. However, the resilience of Enduris against a flooding is difficult to judge. Enduris is primarily focusing on other risks what occur more often for the organisation.

4.5.2. Crisis phases

The crisis management circle consists out of multiple phase as stated in the theoretical framework. The multiple phases give an indication of how organisations prepare their crisis planning, response and recover from a crisis.

Crisis measures, such as scenario planning, crisis communication, information management, GRIP, evaluation and covenants are represented in all the CI sectors and governmental institutions. The governmental institutions and CI sectors have similar crisis measures.

All the CI sectors and governmental institutions have methods for internal and external communication. As stated in chapter two, communication is one of the most important aspects. The CI sectors and governmental institutions have crisis communication or coordination to tell internally and externally what is happening and what the next steps are in the action process. Informing about the problem avoids panic and confusion and stimulates the recovery process after the crisis. This

contributes to the resilience of the CI and the governmental institutions. In addition, the VRZ made covenants with stakeholders in the province of Zeeland. The covenants make clear agreements what the organisation has to do when a crisis occurs. This makes the response phase going more quickly and more efficiently and limiting the impact on infrastructure and citizens, because organisations can act more quickly.

The GRIP procedure is used by all the researched organisations, with a slightly deviation of Enduris who is following the GRIP. The usage of a similar procedure allows a better and more efficiently cooperation between organisations. This contributes to the resilience of the organisations, because a common procedure leads to less miscommunication and to an effective and efficient way of resolving the crisis.

Last but not least, evaluation is a standard measure in the CI sectors and governmental institutions. Post crisis actions help an organisation in the future to improve the crisis resilience by including lesson learning and documentation. By incorporating these experiences into the plan, the organisation can move closer to being resilient. The experiences are put into new prevention measures which are more resilient to new crisis.

The different CI sectors and governmental institutions also have different measures. In table seven an overview is provided of the different crisis management measures in the different phases.

Phase/ Organisation	Preparation	Response	Recovery	Prevention
VRZ	MOTO	Leadership, advice	Temporally measures	Testing, workshops
Municipality of Reimerswaal	Information gathering	Information provision, shelter citizens	Aftercare citizens	-
Scheldestromen	-	-	Medical/psychological recovery	Testing, spatial planning, monitoring
Evides	-	Mobile water tanks/purification	Damage claims	Poolingcontract, Delivery plan, information security
Enduris	Measure matrix	-	KPI's	Data enrichment

Table 7: The variation of crisis measures in the different crisis phases. (Source: Personal collection)

Every sector has its own measures to react, response and recover to and from a crisis. The CI sectors and governmental institutions are the specialist in their own field and know what crisis measures are best. However, specialization can also lead to fragmentation among the CI sectors and governmental institutions. There is a need for an integral way of alignment for priorities. The VRZ has a special role in this, because it acts as a central point for information exchange and communication for different CI sectors and governmental institutions. A good balance between specialization and integration is an important aspect for resilience. On the one hand, specialization is needed to better respond and recover to and from a crisis. On the other hand, the different sectors need to have a multi-disciplinary coordination what requires integration.

4.5.3. Incorporation of cascading effects

A cascading failure is an indirect consequence of a flooding event. If the cascading effects are known, organisations can adapt their crisis management plans in order to deal with or limit the impacts of cascading effects. In table eight, the identified measures against cascading effects in the studied sectors can be seen.

Organisation	Measures against cascading effects
VRZ	GIS mapping including crisis scenarios
Municipality Reimerswaal	GIS map of VRZ
Water board Scheldestromen	Mapping cascading risks and infrastructure research
Evides	Emergency water procedure and joint tool usage
Enduris	Smart usage of infrastructure and infrastructure research

Table 8: Measures against cascading effects (Source: Personal collection)

The VRZ developed a large GIS map containing information about the CI and as well as other sectors. The GIS information is giving by the other sectors and organisations and the information is asked during meetings of the VRZ. The GIS map gives an overview of all the present networks within Zeeland. The GIS tool is contributing to the resilience against cascading effects, because it helps the VRZ to get an image of the CI inside the province of Zeeland and in the different municipalities. The GIS information can be used to make a better preparation plan to protect important assets in the region. Moreover, the GIS map is used to inform municipalities, like Reimerswaal, about the important infrastructure and assets lying in their region.

Scheldestromen is mapping the possible cascading effects in their risk matrix. The cascading effects from both Scheldestromen as well as from other CI sectors are taken into account. The water boards have to include possible impacts of the failure of their infrastructure on other CI sectors. Scheldestromen is also including the cascading effects of other CI's, such as electricity. The cascading effects are taken into account as much as possible. In addition, Scheldestromen is conducting research towards their infrastructure. The research investigates where the electricity wires are located and how high the water level needs to come to cause a short circuit. The mapping of cascading effects and the research is contributing to the resilience of Scheldestromen. If the cascading effects are known, the water board can take measures to limit the effects of other infrastructures. Scheldestromen is already doing this by heighten their electrical infrastructure at pumping stations. This will improve their resilience against a flooding, because the infrastructure is less likely to be affected by a high water level.

Evides is using a joint tool with the drinking water sector to investigate risks and to identify cascading effects. The tool helps Evides to identify risks and possible cascading effects of other sectors. The tool is supervised by the national government (ILT). The usage of the tool is contributing to the resilience of Evides, because Evides can identify risks and adapt their crisis plans measures. Moreover, the information can be shared with other drinking water companies what is increasing the learning process between the companies. This is also vice versa, when another drinking water company experiences or identify a risk, they can share their learning results to the other companies making them more resilient. In addition, Evides has an emergency water plan. When the drinking water supply fails due to a power outage, Evides can deliver drinking water to affected region.

Enduris can limit the cascading effects by smart usage of their infrastructure (figure eleven). Enduris can minimize the cascading effect by using this solution. The resilience is enlarged, because they can adapt their infrastructure to limit the cascading effect from a disruptive event. Hereby, a minimum amount of organisations and activities are affected by such a disruption. Enduris is conducting

research towards their infrastructure. The research involves calculations at what water level a certain part of infrastructure is experiencing a short circuit. This research is enhancing the resilience of Enduris now and in the future, because it visualizes what points are weak spots in the system. When this is known, Enduris can adapt its infrastructure to a more resilient infrastructure, enhancing the resilience. This research is still going on, because of the vast infrastructure system of Enduris.

However, the identification of cascading effects is still a recent development. The development of tools to identify cascading effects is like Marco de Feiter stated; “still in the beginning phase”. This can be seen at for example Enduris. Enduris is doing research towards its own infrastructure and is putting the results into a GIS map. Other sectors are doing researching their infrastructure as well. This means that cascading effects cannot be predicted and analysed precisely, because the sectors are busy developing and fine-tuning the tool. However, the sectors are well aware of cascading effects and are therefore researching their infrastructure and developing a tool to create an overview of their infrastructure. In addition, the private sector uses information security to protect their information about their CI and important assets. This is because they do not want to become even more vulnerable as they are already a vulnerable sector where a large amount of activities are dependent on.

4.5.4. Collaboration, exercising and practising

As stated in the theoretical framework, collaboration is an important way to reduce possible damage caused by disruptive events. An overview of the exercises is shown in table nine.

Organisation	Internal practising	External practising
VRZ	System test	MOTO, workshops, meetings
Municipality Reimerswaal	BT training	Exercises with relevant stakeholders
Scheldestromen	System test	OTO
Evides	Crisis procedure	Exercises with stakeholders, municipalities and government
Enduris	Simulation room	Testing crisis line

Table 9: An overview of internal and external practising. (Source: Personal collection)

The crisis management plans are tested on a regular basis. The MOTO plan of the VRZ is developed every four years. The MOTO is put into an annual year calendar consisting of training, exercising and education. The VRZ is practising and exercising via the MOTO with CI sectors and other governmental institutions. This periodic testing is contributing to the resilience. The MOTO includes an annual schedule of exercises with other sectors and organisations. Hereby, the people within the organisations have to know the procedures and the course of actions in case of a crisis event. The collaboration between the VRZ and the organisation(s) participating is amplified, because the organisations know what the other organisation is expecting and know what they have to do. This is enhancing the resilience of both the VRZ and the participating organisation(s). Moreover, the MOTO plan is updated every four years what leads to an adaptive plan which is taking into account lessons learning from the past. In addition, meetings and workshops with all the stakeholders improve the coordination and knowledge of the crisis planning both for the VRZ as well as for the stakeholders.

The VRZ has to do a policy team exercise with every municipality once a year. The municipality of Reimerswaal is exercising a realistic scenario together with the VRZ. Both the resilience of the VRZ and the municipality is enlarged, because both organisations are attuned with each other. Hereby, the employees of the municipality know what to do in case of a risk scenario and know what to expect from the VRZ. The VRZ get to know the organisation and procedure of the municipality and if needed can provide feedback for improvements. Hereby, the municipality can adapt their crisis plan and

make it more resilient for a real crisis scenario. In addition, the municipality is exercising with other CI as well, such as Evides or Scheldestromen. Herewith, the employees of the municipality know what to do in case of a risk scenario and know what to expect from these CI sectors.

The crisis management plans at Scheldestromen are tested on a regular basis with a multi-year policy plan. The policy plan describes the way in which the organisation prepares for crisis in the next four years by means of training, education and practising. The multi-year policy plan consists out of an annual program with proposed activities and exercises. The exercises of Scheldestromen vary in size, regarding what kind of crisis scenario is tested. The exercises make Scheldestromen a more resilient organisation, because the organisation itself is tested every year with a variation of exercises. Herewith, the employees within Scheldestromen know what do to and know what to expect in the course of action. The water board also has consultations with the VRZ about exercise evaluations. The evaluations contribute to the resilience, because the lessons that are learned from the exercises can improve the crisis planning of Scheldestromen and make it a more resilient crisis plan. In addition, Scheldestromen is educating their employees. The education enhances the resilience, because the employees are aware what kind of procedures to follow and what to do during a crisis situation.

The crisis management procedure of Evides is tested on a regular basis –twice a year- with operational exercise and multi-disciplinary exercises. The organisation is getting closer to being resilient by the periodic testing and the multi-disciplinary exercises. The organisation within Evides is tested frequently and the every layer of the organisation is involved in the exercises. The employees within the organisation are tested and therefore know what to do and what to expect in the course of action. Evides is also exercising with a large variety of organisations and governmental institutions, such as the municipalities or ILT. This is not only contributing to the resilience of Evides, but also from other organisations. Evides know what to do in a certain situation and what to expect.

Enduris is practising crisis scenarios in a simulation room. The simulation room is used to test crisis scenarios and in order to improve the preventive measures of their crisis management. Enduris is intensively exercising with the VRZ whereby the crisis line is tested. The crisis line is checked multiple times a year in a crisis line test. The resilience of Enduris is improved by the simulation room and the crisis line test. Enduris can test a crisis scenario within the simulation room where the organisation of Enduris is tested. Due to this testing, the internal employees know how to react and what to do when a real crisis occurs. There is less chance of panic and employees know the procedure of the actions what need to be taken. The crisis line test contributes to the resilience, because the crisis procedure between Enduris and the VRZ is tested. Both the organisations are better prepared for a real crisis, moreover, because the crisis line is tested frequently.

5. Discussion

In this study, research was done towards the crisis management plans in three CI sectors and two governmental institutions in relation to cascading effects. By conducting a literature study and a practical study, the research questions were obtained. Both in the literature study and the practical study are a number of discussion points.

During the literature study it was difficult to collect data, because private institutions have a confidentially regulation on information and data. The regulation prevents that the private sectors (Enduris and Evides) do not get more vulnerable regarding their infrastructure. Because the private sector have a confidentially regulation on the data, the researcher could not access the information which meant that limited data was available for the research. During an interview the researcher was given access to a database through which the researcher had access to more data and information about the private sector. However, it must be said that the data of the private sectors on the database was again limited, because of the confidentially regulation.

The strong point of this study is that a lot of public data was accessible. The public sector is openly sharing data with the public. Due to the database, the researcher could easily retrieve and read even more public documents from the public sector and governmental institutions. However, due to the limited research time a choice had to be made what documents had to be analysed in depth. Moreover, some information and data from the database and from other sources is old data what decreases the quality of the results and thus of the research.

Everybody who was contacted participated in the interviews and the interview response was 100 percent. However, a second round of interviews with the experts would have led to more reliable results, because the collected data could have been verified and more in-depth questions could be asked about crisis management and the link to cascading effects. The more reliable results will lead to a more reliable conclusion. A second round of interviews would be possible if the researcher had a longer research period.

The interviews were conducted with top experts in the field of crisis management and crisis prevention in mentioned governmental institutions and CI sectors. The interviews with the experts led to a quality set of data and a clear image of how the plans are put into practice. The interviews with the experts went well and all the questions on the question list were asked and answered. However, the difference between the interviews with the public sector and the private sector are remarkable. The interviews with the public sector led to more sources and pieces of information. This stimulated the research, because more information was accessible than before. The interviews with the private sector were stricter. The interviews were primarily focused on the content of the crisis plan and led more to a confirmation of the already collected information rather than more useful information for the research.

The communication and cooperation between the researcher and the research group was at a high level. The ideas, results and findings of the research were shared with the research members. The research team has a big network and know a lot of people and experts regarding crisis prevention and crisis management. The level of communication led to suggestions for interviewees and new possibilities of information sources. The cooperation between the research team and the researcher led to the sharing of results and information. Hereby, the researcher could learn from new developments regarding crisis management and the causes of cascading effects in the CI sectors.

6. Conclusions and recommendations

6.1. Conclusions

This thesis answers the following main question: *'In what way does crisis management enhance the resilience of the critical infrastructure and governmental institutions in relation to cascading effects of a possible flooding scenario in the municipality of Reimerswaal?'* A qualitative research (desk research, interviews and observations) has been conducted to investigate crisis management in critical infrastructure sectors and governmental institutions in relation to cascading effects, in the municipality of Reimerswaal. In order to answer the main question, four sub-questions were answered.

Paragraph 4.1 has shown that the governmental institutions and critical infrastructure sectors have crisis plans in case of a flooding scenario. The incorporation of a flooding scenario in their crisis planning enhances the resilience of the organisation, because the organisation is prepared for a flooding scenario. The critical infrastructure sectors and governmental institutions are pro-active and understand the flood risk what is developing a level of comfort when a crisis occurs.

On the basis of the crisis management cycle, it is investigated how the pro-action, preparation, response and recovery phases are represented. This is stated in figure six until table nine. The critical infrastructure sectors and governmental institutions have similar crisis measures, but also unique measures regarding their services. This enhances the resilience of the critical infrastructure sectors and governmental institutions, because they understand the risks, prepare for the risks and hereby develop effective response measures. The crisis cycle also shows a certain degree of specialization of crisis measures what can lead to fragmentation of the integral alignment. However, the VRZ plays an important role of integration what is serving as a communication and information exchange body within the province of Zeeland.

The cascading effects are identified as much as possible and incorporated in the crisis planning as stated in table nine. The critical infrastructure sectors as well as the governmental institutions are mapping the cascading effects and are conducting research towards their infrastructure and possible cascading effects. This enhances the resilience, because the organisations get an image of their infrastructure, but also infrastructure from other sectors. This can be taken into account during crisis preparation planning. However, identifying cascading effects is still a recent development and progress still has to be made to create reliable and detailed tools to identify cascading effects in critical infrastructure. In addition, the information security of the private sector is withholding information about infrastructure and assets what important for in the tool to identify cascading effects.

As last, chapter 4.5 has shown that the critical infrastructure sectors and governmental institutions are frequently exercising g with each other. They practise internally once every year or once every two years and the employees are trained within the organisation. The exercises and practises consist out of crisis scenarios with substantive depth of a real crisis event. This enhances the resilience, because the crisis plans are regularly tested and evaluated, which is improving the adaptability of the crisis plans. Moreover, the employees know what do to and what to expect in the course of action, because they are well-trained and prepared.

This qualitative research concludes that the crisis management plans enhance the resilience of the critical infrastructure sectors and governmental institutions. The cascading effects of other critical infrastructure sectors are identified and taken into account as much as possible.

6.2. Recommendations

6.2.1. Recommendations for the researched sectors

The interviews during the research have revealed that the VRZ is more asking for information to the critical infrastructure sectors rather than be shared by critical infrastructure sectors. Normally, the VRZ is receiving the information from the critical infrastructure sectors a few times a year. However, the VRZ is more asking for information than receiving it. It is recommended that the critical infrastructure sectors share more detailed information about their infrastructures more often with the VRZ. Over time, this can improve the resilience of the province of Zeeland, because the VRZ knows where the most important assets and infrastructures are located within the area of influence.

Desk research has revealed that Scheldestromen did not publish all their partial plans. Only four of the six partial plans are published. It is recommended that Scheldestromen publish the missing plans on their website and share it with the public. The missing partial plans concern; the business continuity plan and the water purification plan. Other sectors and CI sectors can use this kind of information to identify risks while doing research towards the water board Scheldestromen and its infrastructure, such as Evides which has a benefit to know the quality of surface water for their drinking water production.

Research has revealed that the private sector is extremely careful with their information. This is of course understandable regarding the services they provide and their vulnerability. However, this is also withholding the understanding of the infrastructure and important assets to the public sectors. They would like to know more about the infrastructure of the private sector. A more open environment of information sharing can lead to a better understanding of cascading effects and an integral approach and understanding of critical infrastructure and limiting the impacts of failures. In order to prevent that information is going to the outside world, a small team of different critical infrastructures and governmental institutions can be developed to share information and developments.

Research has revealed that research towards cascading effects is in the development phase in the critical infrastructure sectors and governmental institutions. It is recommended that research towards cascading effects is continued, because identifying cascading effects can have be a major contribution to crisis preparation. The GIS tools and research within the organisation can give an important insight of critical infrastructure and important assets. This information can be shared with other sectors who can adapt their crisis plans, because they know more about the interdependencies and possible cascading effects that may occur.

6.2.2. Recommendations for Resilient Deltas

The interviews with the municipality of Reimerswaal and Scheldestromen have shown that the interviewees were dissatisfied about the lack of communication from the side of the research group. It is recommended to improve the communication between the consortium partners. Hereby, the partners of the consortium have an insight how the research is progressing, how research process is going and see what the intermediate results are. This can have a positive effect on the research of Resilient Deltas, because the information can be verified by the consortium partners. The design of an information exchange platform could be an option to strengthen or schedule multiple meetings with the consortium partners to discuss the research.

The interviews have shown that some interviewees argued that the amount of two workshops is not sufficient over a two year research period. The municipality of Reimerswaal and Scheldestromen are

positive about the workshops, because they provide new insights on cascading effects and critical infrastructure in Zeeland. It is recommended taking this into account and maybe organise another smaller workshop with the consortium partners. This would create the opportunity to share and verify intermediate results and at the same time create the opportunity and ask for new information.

The research has shown that the results of private sector (Enduris and Evides) in this research are not in full detail, because of confidentially data. The information could be available if an earlier covenant agreement would have been made between the private sectors and the Resilient Deltas group. It is recommended for next time to make a covenant agreement on the beginning of the overall research. This can improve the quality of research done by interns, because they have access to detailed information. This would result that Resilient Deltas would have a more detailed research from interns, which contribute to the overall research.

6.2.3. Recommendations for future research

It is recommended to investigate more critical infrastructure sectors in Reimerswaal. Such a study could be applied within the same time period, but with the focus on other critical infrastructure sectors. Critical infrastructure sectors and the government are recently conducting research towards ICT and telecommunication infrastructure in their system regarding failures and interdependencies. It would be interesting to investigate the ICT and telecommunication infrastructure in the municipality of Reimerswaal. The results of that study can be added with this study in order to make a larger picture of the critical infrastructure sectors and possible cascading effects in the municipality of Reimerswaal.

This study is based on both academic literature and local research. Future research could identify how other geographical locations, in the Netherlands, organise their crisis management in relation to a flooded critical infrastructure. Ideas and adjustments could be added to this research or to the overall research of Resilient Deltas.

It is recommended for the future researcher to plan a second interview round with private sectors. Private sectors have most of the time a confidently on their information and limited time in their planning for an interview. A second interview round will give a researcher further ideas and chances to ask more specific interview questions. In the end, this will provide a better research report including more detailed information and data.

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