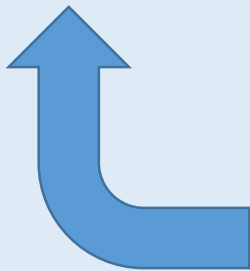
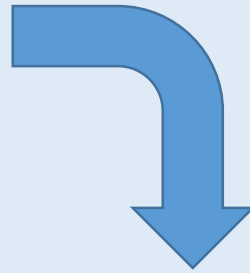


# Learning from the resilience of others:

A comparison between the Netherlands and Chile in dealing with earthquakes



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## List of abbreviations

CSN	-	Centro Sismología Nacional
CVW	-	Centrum Veilig Wonen
EBN	-	Energie Beheer Nederland
MINVU	-	Ministerio de Vivienda y Urbanismo
MISP	-	Ministerio del Interior y Seguridad Pública
NAM	-	Nederlandse Aardolie Maatschappij
NCG	-	Nationaal Coordinator Groningen
NOAA	-	National Oceanic and Atmospheric Administration
NPR	-	Nederlandse Praktijk Richtlijn
OECD	-	Organisation for Economic Co-operation and Development
ONEMI	-	Oficina Nacional de Emergencia del Ministerio del Interior y Seguridad Pública
OrV	-	Onderzoeksraad voor de Veiligheid
PNUD	-	Programa de las Naciones Unidas para el Desarrollo
SHOA	-	Servicio Hidrográfico y Oceanográfico de la Armada
SodM	-	Staatstoezicht op de Mijnen
TNO	-	Nederlandse Organisatie voor Toegepast Wetenschappelijk Onderzoek
UNISDR	-	United Nations Office for Disaster Risk Reduction
USGS	-	United States Geological Survey

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## Foreword

While I lived in Santiago de Chile during the second half of 2016, I worked as an intern at a local NGO, dealing with environmental issues. On an ordinary Summer-Tuesday, while it was 30 degrees Celsius, I suddenly felt my chair shaking and trembling. It was just a short 'sismo' but I was excited because it was the first moderate earthquake I felt in my life. However, it was scary at the same time: is the construction of the building strong enough for this amount of energy? The rest of the office though just kept on working like nothing happened. After work I came home and I asked my Chilean landlord whether he had felt the earthquake and whether he had been scared. His reaction was quite striking: he started laughing. For him this was clearly not a thing, he barely noticed the earthquake. "This is nothing, compared to what we have felt earlier in our lives", he said. He left the house after that statement and let me alone surprised. I became even more surprised when I looked up the magnitude of the earthquake: 6.1 on the Moment Magnitude Scale.

This anecdote is one of the reasons why this document lies in front of you. The earthquake has started a thinking process inside my head on the behaviour of Chileans. Why are they so relaxed about these earthquakes? And actually, why is there no damage at all after a 6,1 earthquake? And why is it so different compared to the situation in the Netherlands?

With help of these questions I started several brainstorming sessions in Chile during work and during my travels. At work I talked with several people and during my travels I looked at buildings and cities on how they are planned and constructed to prepare for disaster. This gave me inspiration and it made clear that Chileans have a mind-set for preparation before a disaster.

Before the start of the thesis, I would like to thank a few people. In the first place, I need to thank the people from ChileAmbiente, the NGO in Chile for which I worked, for inspiring me and giving me information on the 2010 earthquake and tsunami disaster in Chile. Secondly, all my friends in Chile deserve thanks for having discussions with me on my subject of study and giving me several insights on how they live with earthquakes. Thirdly, I would like to thank all the interviewees that have given me an extensive insight into the earthquake situation in the region of Groningen. Finally, I would like to thank my supervisor, Ferry van Kann, for having discussions with me on how to improve and change my thesis on different aspects.

After all expressions of gratitude, I would like to say that I hope that this document is a small start towards an earthquake resilient Groningen and that you enjoy the reading of this thesis.

## Abstract

Earthquakes in the Netherlands are a relatively new phenomenon. Since just a few decades there have been earthquakes induced by gas extraction in the region of Groningen. This inexperience and the financial benefits of the gas field are two of the main causes why decision-making on this matter is difficult. Chile however, has a long history with earthquakes and the authorities therefore have a long experience on how to prepare and to deal with earthquakes. This research looks whether there are lessons to be learnt by the Netherlands from the Chilean method that can be used to improve the resilience against earthquakes, with help of the Adaptive Capacity Wheel.

Resilience is a concept suitable for earthquake disasters, because it describes how a region or country can come back from a negative influence. A resilient system can reduce the failure probabilities. The other concepts that decide whether a country is resilient are vulnerability and adaptive capacity. These three concepts together determine whether a country can recover from disaster. Therefore, the concept of Adaptive Capacity Wheel is a suitable tool for measuring resilience. The wheel determines the level of adaptive capacity of a country on basis of several dimensions. Because of that, it also makes it suitable for comparison. The next step is to create a possible policy learning. There are several grades of policy learning, from coercive to low level of lesson-drawing. This research most probably only incorporates voluntarily lessons, because the Netherlands and Chile do not have direct legal bindings.

Although there are a lot of context differences, the Netherlands can take inspirational lessons from Chile. In the first place, the showing of direct leadership. If the national government shows that they really care about the safety and liveability of the region trust will be much higher. Secondly, technical solutions are the main asset of Chile's method to ensure safety. If the people of Groningen need to feel safe, high technical standards for safety are essential. Thirdly, all information on earthquakes needs to be public and people need to be encouraged to ensure their own safety, to improve the ability to improvise and the resilience of the inhabitants themselves. Finally, the acceptance of the authorities that they will have to deal with a huge task by seeing the situation as a natural disaster. This will cause that the government acts more decisively and will do everything to restore the region.

With these lessons the region of Groningen can possibly be helped and the decision-making process improved. In this way the resilience of the region and the inhabitants can be improved. On top of that, this research shows whether the Adaptive Capacity Wheel is a good way to compare two countries and if it is useful for the method of policy learning. Although context barriers, for example difference in earthquake intensity and difference in political system, play a role, it is certainly possible for the Netherlands to learn several lessons from Chile.

## Keywords

Earthquakes; Resilience; Adaptive Capacity Wheel; Chile; the Netherlands

# 1 Introduction: earthquakes in two different contexts

On the 16<sup>th</sup> of August 2012 an earthquake occurred in the little village of Huizinge, in the middle of the province of Groningen, in the northern part of the Netherlands. This earthquake had a magnitude of 3.6 on the Moment Magnitude Scale and is the heaviest earthquake that has ever been recorded in the province of Groningen. This earthquake caused a lot of damage to houses of people and vulnerable buildings, for example schools and churches. On top of that, it caused that a long-running societal debate became extra fierce (ANP, 2013).

The province of Groningen did not have a history in earthquakes, until the moment a gas field was found under the surface of the region in 1959. The state, with help of the oil companies Shell and Exxonmobil jointed in the company NAM, started to extract gas from that period and became an important part of the growing prosperity in the country (OrV, 2015). The field has been for 30 years one of the major gas suppliers in Europe (Amin, 2015). However, the extraction of gas from the ground has a negative effect: it induces earthquakes. The first earthquakes took place in the 1980s and on average around 30 to 40 earthquakes occurred every year. Since then, these earthquakes had a relatively low magnitude, but have caused minor and major damage to buildings in the region (Van Es, 2012). It means also, that it would have been possible to adapt to earthquakes within these 40 years. Something that did not happen properly and still needs improvement (OrV, 2017)

The situation is a difficult one for the people living in the region. They are afraid that something can happen to them. It is for example possible that a house collapses if an earthquake is strong enough. On top of that, the worth of their houses is declining (Van Es, 2012). However, the government preferred to profit from the gas revenues, than doing research and ensuring the security of the local people, The Dutch national government denied for twenty years that the earthquakes were caused by the gas extraction and that people could be at risk (Van den Berg, 2015a). On the contrary, they focused on getting the maximum revenue from the gas field. Partly because of this, the trust between the people of Groningen that are affected by the earthquakes and the authorities is minimized (Amin, 2015; OrV, 2015).

In Chile however, earthquakes are a common, every-day, phenomenon. It is the case that in Chile earthquakes with a magnitude around 3.0 are common practice for the people and the authorities. It is possible that there are around 20 earthquakes on one day, that have a magnitude of 3.0 or higher (CSN, 2016).

A recent example of a major earthquake in Chile occurred on the 25<sup>th</sup> of December in 2016 in the southern part of Chile on the island of Chiloé. Around 5000 people were evacuated for a possible tsunami and some houses and roads were damaged. On top of that, 21,000 houses were cut from electricity for a day. However, it did not cause a major stir within the population of the region (Reuters, 2016). A much stronger earthquake occurred in September 2015 near the city of Coquimbo, of 8.3 on the scale of Richter. This one caused that around one million people were evacuated from the coasts of Chile. The material damage was high, but 'just' 13 people lost their lives, which is not a lot compared to major earthquakes in other countries in the same period of time, for example the Dominican Republic or Italy (Doherty, 2015).

There are some reasons for this relatively low amount of problems caused by major earthquakes in Chile. In the first place, Chile is well-prepared for a possible earthquake hazard. Evacuations are exercised every two-years, warning systems are really precise and authorities know how to react when an earthquake occurs. Secondly, building codes make sure that buildings are not destroyed by an earthquake and remain standing even if the magnitude is 9.0 (Franklin, 2015). Thirdly, the country has a long history of earthquakes. People know that they live in a hazardous country and they act to this situation. Because of the resolute acting by the authorities and the behaviour of the people there is also a lot of trust in the technical solutions and knowledge of the government (Long, 2015).

A real problem for Chile occurs when earthquakes have a very strong magnitude. Next to that, the extra risk of tsunamis makes it even more challenging for the country to deal with these problems. An earthquake in 2010 is a negative example of how disastrous an earthquake could be, also for Chile. During this earthquake, hundreds of deaths were counted and cities were severely damaged, caused by the earthquake itself and a tsunami pushed by the earthquake (Carroll, 2010). However, the aftermath was dealt with in an efficient manner by the authorities. The city of Constitución for example was rebuilt and made stronger against earthquakes together with the local inhabitants (Long, 2015).

These examples make clear that Chile knows that it is situated in a hazardous area and that it knows how to deal with that situation. In the Netherlands though, earthquakes are a relatively new phenomenon (Amin, 2015). Therefore, it is of interest for the Netherlands to research the method of Chile in dealing with earthquakes. This research compares the two countries and tries to improve the method of dealing with earthquakes in the Netherlands in this way.

## **1.1 Research Question**

To find answers about learning from other countries dealing with earthquakes, it is necessary to have clear research questions in the first place. In this section the main research question will be given. With help of this question, a clearer view will be created on the learning possibilities of the resilience of earthquakes:

*“What and how can the Netherlands learn from the resilience against earthquake hazards in Chile?”*

To ease the research, the main question is divided into a few sub questions:

- How can resilience and adaptive capacity against earthquakes be defined in theory?
- How can the levels of resilience against earthquakes of the two regions be determined?

- What is the current knowledge level of national and local authorities in general on the case of earthquakes in the Netherlands and Chile?
- What are the different approaches of dealing with earthquakes in the two countries?
- In which policy areas can the Netherlands learn from Chile to improve resilience against earthquakes?
- Which methods of policy transfer or learning can be applied?
- What are the context barriers to transfer policy ideas between Chile and the Netherlands to improve earthquake resilience?

## **1.2 Research Objectives**

The first goal in this research is to find out whether it is possible to learn from the resilience of others when dealing with earthquakes and whether different methods possibly can be transferred to improve the process and method of handling during a hazard in that country. The second goal is to improve the method of policy transfer for planning practice by making use of a new approach for comparing two countries. The third and last goal is to improve the resilience against earthquakes in the Netherlands by learning from the method of Chile.

## **1.3 Scientific Relevance and connection to theoretical debate**

Resilience is a concept that is of growing importance in planning practice, because it can help to protect people and the built environment against for example natural hazards (Folke et al., 2010). Earthquakes are an example of such hazards, that can have a strong impact on the human environment. Societies need a fierce resilience to deal with the effects of a possible event with a devastating power. If this is not the case, societies can be severely disrupted (D'Amico, 2016). There is difference in the level of resilience against earthquakes between regions (OECD, 2013), and it is therefore interesting to organize learning between regions on how to deal with earthquake effects and to transfer ideas and policies between countries.

However, there is a knowledge gap in planning literature on in which way it is possible to transfer ideas of resilience on earthquakes between regions. Stead (2012) for example denies that the promotion and supporting of best practices in planning will increase the transferability between regions. He states that countries and regions are too different in context to copy or emulate best planning practices. On top of that, it is hard to transfer the method in itself because the essential tacit knowledge of a planning method can not be perfectly translated. Therefore, Stead (2012) states that it is of importance that a more detailed examination and research on the transferability of planning techniques and methods is done. Also the transfer process is often hard to understand for local authorities, which downgrades the level of

success of the transfer. A more rooted and deeper perceptive and understanding of policy learning or transfer is necessary to create a successful framework for transferring policies and ideas (Dolowitz et al., 2012).

This research elaborates on the doubts of Stead (2012) and Dolowitz et al. (2012) whether policies from a different region can be implemented in another region and on their statements that deeper research is necessary. This research starts off with an approach for comparing regions to make clear what the lacking aspects are of the countries concerning earthquakes. An example of a concept for doing this is the Adaptive Capacity Wheel of Gupta et al. (2010), which rates the adaptive capacity of a city or region on basis of several dimensions and criteria.

#### **1.4 Expected results for academia in general and planning in particular**

As Rose (1991) states, comparison is a very old concept, but lacking on a clear theory. There is need for a theory, when differences between two countries are observed. Dolowitz & Marsh (2001) give an example of such a theory, with explaining how policies can be transferred, what contents can be transferred and in which degree. For planning in particular the improvement of the notion of policy learning and transfer is of high interest, because the method emphasizes the will of improving the planning practice of a region. The capacity of planners will increase if the method of policy learning is improved (Booth, 2011). However, there is lacking knowledge on the transfer possibility of resilience.

This research will help to improve this by comparing the two cases and researching the possibility of policy transfer from the donor country to improve the resilience against earthquakes in the receiving country. This will add to the understanding of policy learning and transfer debate and open new insights for transferring ideas and policies that increase resilience between regions. On top of that, planners will have a better notion on how policy learning or policy transfer should take place.

#### **1.5 Societal Relevance**

This research helps to improve the approach for dealing with earthquakes in the Netherlands. In this way, the country and especially the region of Groningen can be made more resilient for earthquakes with help of the possible lessons learned from Chile. On top of that, a possible general method for transferring best practice ideas for improving resilience between countries is created. In this way countries or regions vulnerable to earthquakes can be helped in a better way by planners.

#### **1.6 Expected results for planning practice**

This research is looking for an approach that can help learning from other regions or countries when dealing with earthquakes. This is done with a comparison between two countries, the Netherlands and Chile. The research focuses on trying to organize policy learning between these two countries, which is a relatively new concept in the earthquake research. There are methods on how to enhance seismic resilience of regions (Bruneau et al., 2004), how to measure with help of indicators resilience (Khalili et al, 2015) and the use of a model in one country for measuring earthquake preparedness in another country (Jang et al, 2016).

This research enhances the knowledge for creating such a new approach. This is done by using the Adaptive Capacity Wheel to compare the Netherlands, as receiving country, and Chile, as best planning practice example. From this comparison it becomes clear in which areas the policy of the Netherlands can be improved and policies can be transferred. This report will be in this manner the first example and forms a framework for future research to implement policy learning when dealing with earthquakes.

## **1.7 Outline**

The report will be structured as following. In the next section, chapter 2, the theories on resilience, adaptive capacity and policy learning are explained in order to develop a framework for executing the research. Chapter 3 focuses on the methodology and therefore explains how the research is conducted. Chapter 4 explains the mechanisms of natural and induced earthquakes to create a sense of the different contexts of the two countries. Chapter 5 contains the results and findings of the research. Chapter 6 discusses the results and gives several conclusions and answers based on the research questions. The last section, chapter 7, is the reflection and looks back on the research process to explain what could be improved or is lacking and explains what this research has added to planning practice and theory.

## 2 Theoretical Framework: Resilience and Policy Transfer

In this chapter an overview is given of various theories that are used to support the research and to create a conceptual model that functions as the guideline of the research. Theories are desired for every case study research because it forms the basis to start from and it gives a so-called blueprint to create a research. It ensures that the researcher has a strong guidance, while executing a research (Yin, 2013). The theories focus in the first place on the concepts of resilience and adaptive capacity, because they form the basis for creating more safety for earthquakes. In the second place, it focuses on the concepts of policy learning, because one of the aims of the research is to let the Netherlands learn from Chile.

### 2.1 Resilience

Earthquakes are a strong and devastating hazard that have a main impact on society (D'Amico, 2015). One of the concepts that is of use for hazard management, and thus for dealing with earthquakes, is the concept of resilience. Being resilient or adaptive is key to individuals and communities to be able to return to normal state or become stronger after a negative shock (Shaw & Maythorne, 2011). As stated by Vale & Campanella (2005) urban resilience is the capacity of a city to bounce-back from a hazard event. The most important part of resilience for a city in a hazardous surrounding is to change and adapt after a shock. Changing the approach of dealing with a sort of hazard makes a city stronger and therefore more resilient for that specific hazard (Grøtan et al., 2010).

The basis of the method of resilience is explained by Davoudi (2012). She distinguishes three different sorts of resilience: Engineering resilience, Ecological resilience and Evolutionary resilience. Engineering resilience forms the original basis of resilience and is defined as the ability of a system to return to an original state or back to a single equilibrium after a shock event (Holling, 1986). It can also be seen as the elasticity of a system. How higher the elasticity or the level of resilience, how much easier it comes back to its original state (Simmie & Martin, 2010).

Ecological resilience is different, because it also focuses on how much disturbance a system can receive before it changes. Therefore, ecological resilience does not focus on one single equilibrium, but has multiple equilibria and focuses on having a buffer to resist negative change (Folke et al., 2010). In this way it can adapt to a different method, because the multiple equilibria give several possibilities to act to. In this way it is possible that a system functions better after the shock than before (Simmie & Martin, 2010).

Engineering and ecological resilience both focus on a situation that does not change constantly, but focuses on a state that changes through direct shocks. The last sort of resilience does that different and is called evolutionary resilience. This theory does not focus on equilibria of any sort, but says that systems are in a constant change, also when there are no external disturbances. It rejects that the system gets pulled or pulls itself towards any sort of equilibria (Boschma & Martin, 2007). A system needs to be able to adapt and transform always if there are stress and disturbances. This means that a system always is able to change its method of dealing with for example earthquake hazards when it is necessary (Davoudi, 2012).



According to Bruneau et al. (2004), these ideas are very important when dealing with earthquake hazards. An abrupt change, which occurs when an earthquake takes place, can downgrade the performance of a system and even let it fail. A resilient system has in such situation three characteristics: it has reduced failure probabilities, the consequences for economy and people's life are reduced to a minimum and the recovery time to get back to a normal state is reduced to a minimum.

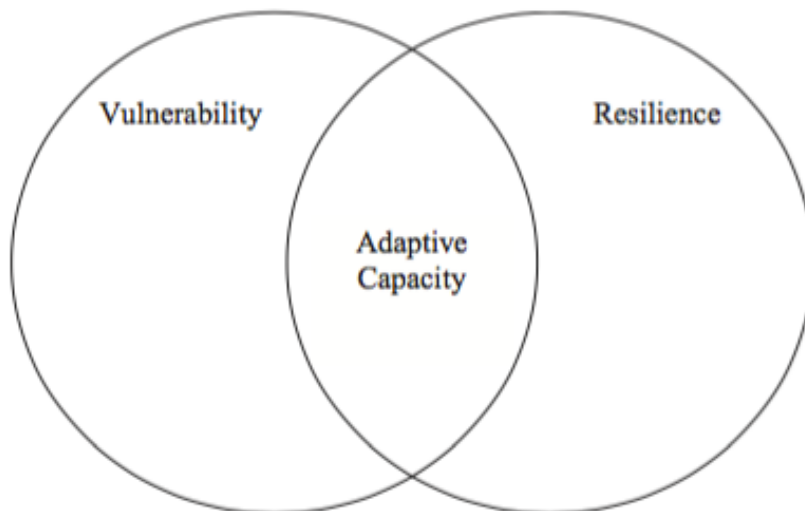
Therefore, a region can be defined as resilient against earthquake hazards, when it has enough strategies to cope with them. As stated by Bruneau et al. (2004), the concept of resilience is the collection of preparation measures to prevent damage caused by hazards and aftershock interventions to make the damage impacts as small as possible. In their definition, seismic resilience is the concept that focuses on local communities and authorities to mitigate before the event and helps to prevent social disruption by implementing recovery activities after a disrupting earthquake. In this sense it mostly focuses on the concept of ecological resilience (Davoudi, 2012).

Different methods must be available to be able to cope with the different situation and to adapt to the occurring situation (Dawley et al., 2010). It is considered that a hazard event consists of four different phases:

- Planning and mitigation
- Preparedness
- Response
- Relief and recovery

These four phases decide whether a region can be resilient against a negative event (Khalili et al., 2015). During these phases it has to be kept in mind, that earthquakes are difficult to prepare for, because it is difficult to forecast when, where and how it will occur, in the case of a natural earthquake (Berkes, 2007). Induced earthquakes are different, because of the anthropological causes (OrV, 2015). It means that actors have a choice to stop the occurrence of earthquakes.

However, the concept of resilience does not completely stand alone as the 'protector' of regions, but is dependent on other notions. As stated by Gallopin (2006) and Engle (2011), there are strong connections between the concepts of vulnerability, adaptive capacity and resilience. This is displayed in figure 1.



**FIGURE 1: THE RELATION BETWEEN VULNERABILITY, ADAPTIVE CAPACITY AND RESILIENCE. ADAPTIVE CAPACITY PLAYS A DECIDING ROLE IN DETERMINING THE LEVEL OF VULNERABILITY AND RESILIENCE (ENGLE, 2011).**

### **2.1.1 Vulnerability**

Vulnerability has been defined differently by several authors. The main definition for this research is that vulnerability means the level of exposure to external negative influences or stress (Adger, 2006). Next to that, it can be seen as the possibility for external influences to change something in the system or to disrupt it (Turner, 2003). The level of vulnerability of a system depends therefore on three concepts: sensitivity, capacity of response and exposure. Sensitivity means the level of modification in a system caused by a disturbance, external or internal (Gallopín, 2006). The capacity of response is the ability of a system that exists already before a negative disruption. It defines how a system copes with and suffers of the disruption. Many authors also see this as the total adaptive capacity of the system (Gallopín, 2006). Exposure, focuses on the disruption or negative event itself, meaning the level, time and extent of the event. In the sense of earthquakes, the magnitude would be a good measure for this concept. These three concepts in total decide the level of vulnerability of a system. These statements make as well clear that vulnerability can not be seen separately from adaptive capacity.

### **2.1.2 Adaptive Capacity**

Adaptive capacity is the other concept that supports or is complementary to resilience. It tells what the level of available resources and assets are of a system to make adaptation measures and to place investments to improve resilience and to reduce vulnerability (Vincent, 2007). Adaptability, the basis of adaptive capacity, is not a mechanistic or standard basis of a system. It is based on the roles of local inhabitants and actors and leadership of the region in which hazards possibly can occur. It tells something about the ability of the local actors, on how they deal with the possible disruptions before, during and after they occur (Berkes, 2007). Folke et al. (2010) state that adaptive capacity says something about the capability of actors in a region or system to determine the level of resilience.

Therefore, the level of resilience of a region is strongly dependent on adaptive capacity as well as vulnerability. Gallopín (2006) and Engle (2011) make clear in their analyses that there is no

clear distinction between the three concepts, especially when they are taken together. This is displayed in figure 1. This dependence on each other is used in this research by applying the adaptive capacity wheel, which is explained in the next section.

## 2.2 Adaptive Capacity Wheel

Researching different countries on their adaptive capacity level or on their level of resilience can help to understand the causes of vulnerability to an earthquake event and why certain regions are more resilient against earthquake hazards than others. In this way it is possible to find a method for reducing the vulnerability of different regions against this sort of hazard (Vincent, 2007). It can be the connection between vulnerability and resilience, so to improve the knowledge of both notions. This idea is displayed in figure 1 (Engle, 2011).

However, measuring the level of resilience, which is necessary for comparison, is difficult and contains a lot of uncertainty, caused for example by the fact that it is hard to quantify certain components (Yohe & Tol, 2002). These uncertainties are important of notice before measuring is started and need a clear definition beforehand to prevent transfer failures. Vincent (2007) gives an overview of the most important uncertainties while measuring adaptive capacity.

First of all, it is unclear how exactly the normative selection of driving powers behind adaptive capacity functions. It is vague which actor or entity is actually a driving force behind adaptive capacity, because it is not always obvious what their direct influence is and whether that influence is helpful or the opposite.

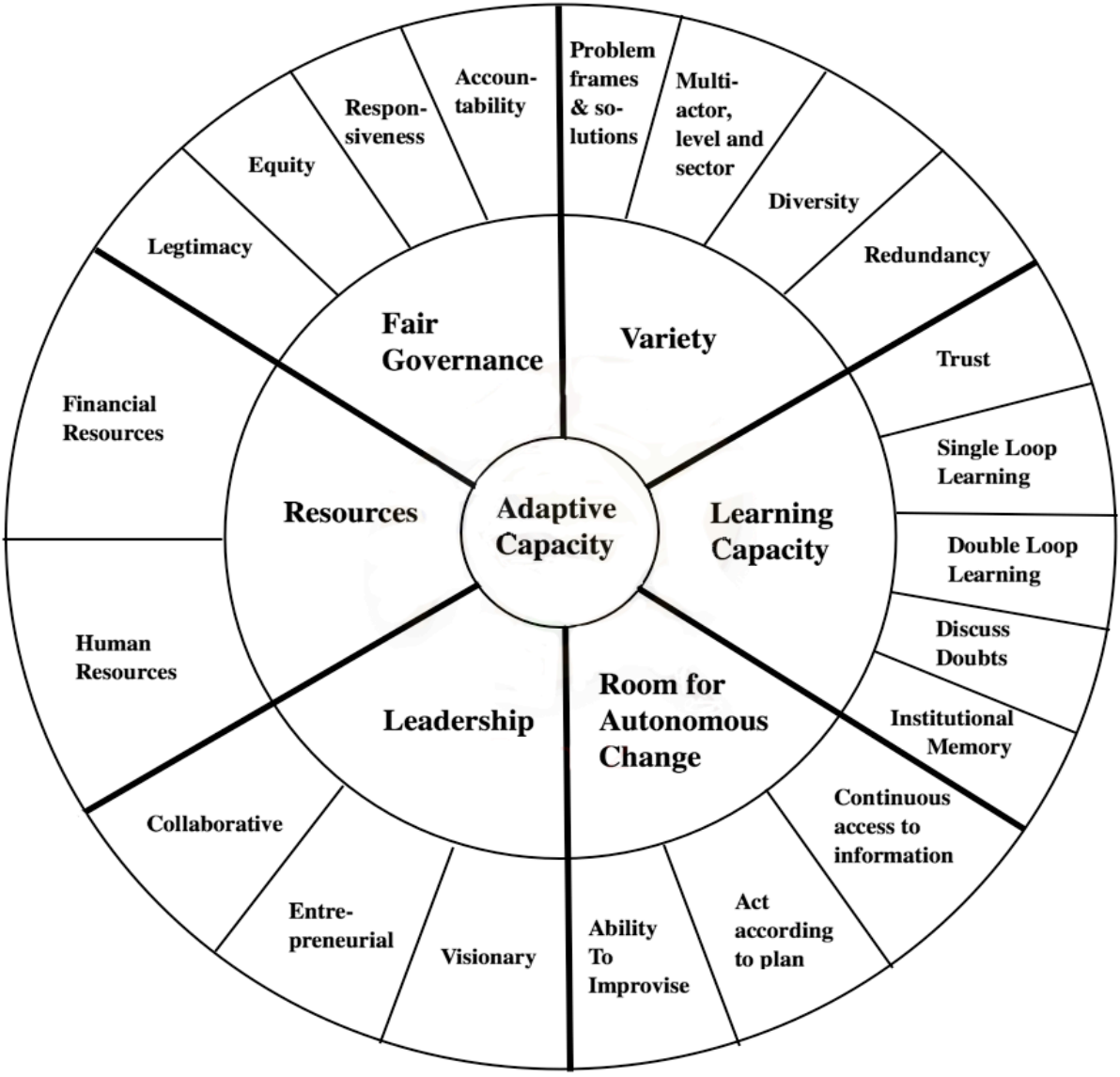
Secondly, indicators that are used to explain the influence of a certain driving force are hard to choose or create. It is key that they accurately capture the variable and that they can have variation and are transferable to use for other actors and driving forces. Vincent (2007) gives the example of governance as a driving force to illustrate this: well organized governance is a strong base for adaptive capacity (Folke et al., 2005), but it is very hard to find clear indicators to assess the level of good governance, because it is hard to quantify.

Finally, it is really hard to determine when and in which manner adaptive capacity changes over time. Scenarios can be developed, but these are always dependent on a certain amount of uncertainty. Firstly, because adaptive capacity is dependent on socio-economic variables that can have a lot variety. Secondly, because adaptive capacity is in connection with exposure and sensitivity, which is always subject to a lot of variation. An example is an earthquake which can cause a sudden increase in sensitivity.

Because of this uncertainty it is necessary to find a framework that deals with them and that deals with the fact that adaptive capacity contains of several dimensions and is in the middle of a variety of processes (Adger & Vincent, 2005; Vincent, 2007). Also because most of resilience frameworks fail in placing a good understanding of adaptive capacity into place (Engle, 2011).

A framework that deals with these problems is the Adaptive Capacity Wheel and is therefore also a useful tool for this research. This framework, created by Gupta et al. (2010) is a

framework that can be used from an institutional perspective and can be used to measure the adaptive capacity of a certain region or a certain project with help of six different dimensions and 21 criteria. These dimensions and criteria are used in this research to determine the level of adaptive capacity of the two countries, the Netherlands and Chile. The wheel is displayed in figure 2.



**FIGURE 2: AN EXAMPLE OF AN ADAPTIVE CAPACITY WHEEL. WITH HELP OF DIFFERENT COLOURS, THE LEVEL OF THE CRITERIA AND DIMENSIONS ARE MADE CLEAR (BASED ON: GUPTA ET AL., 2010).**

First of all, variety. Environmental problems and environmental hazards are situations with a lot of interests and ideas. Therefore, variety is essential by creating no single appropriate ideological framework or policy, but by working with many. In this way, solutions can be found that fit to a certain occasion. An institution can have a high variety if it allows a variety of problem frames and solutions, a variety of levels and stakeholders (multi-level and multi-stakeholder), promotes a lot of diversity of solutions and policies and if it uses redundancy in the short-term period to benefit the best solutions for the long term.

Secondly, learning capacity is important because it allows more understanding based on the experiences in the past or present. On top of that, learning through those experiences and explanation between important actors, improves the trust in each other. The criteria that are therefore important in this dimension are single loop (routine actions) and double loop (challenge against norms and assumptions) learning, clear consideration of uncertainties and doubts, using the institutional memory to learn from past experiences and trust, which is also important for the level of risk perception of the citizens (Bronfman et al., 2016). Therefore, it determines whether citizens are open for learning and whether they want to take personal measures.

Thirdly, room for autonomous change. Social actors must be able to change their behaviour by themselves. Institutions must actually encourage them to do so. In this way they can anticipate themselves for different possible futures and improvise when it is necessary (Folke et al., 2005). Criteria that help to define this dimension are the level of access to information, that actors are capable or are made capable to act according to the plan and that improvisation is possible.

Fourthly, leadership is an important asset to foster change and therefore also to improve the adaptive capacity of a region. The focus is on whether institutions create an environment in which leadership can come forth. The criteria to check if this is the case are whether institutions encourage visionary (solutions and policies that bring a region forward and are robust for the future), entrepreneurial (ensures that decisions are taken) and collaborative (all opinions of different actors should be deliberated about) leadership.

Fifthly, resources. This says something about the ability of an institution whether it really can execute certain plans or policies. Sufficient resources, human and financial are necessary to create plans and to change behaviour for enhancing adaptive capacity (Nelson, 2010). Therefore, the following criteria are used to measure this dimension: human resources (for example labour and scientific knowledge) and financial resources.

Finally, fair governance. Governance of the institution should find a balance between efficiency and effectiveness. On top of that, it means that the policy-making is legitimized by society and that every decision is as transparent as possible for every actor. Most important goal is that every group of actors is treated evenly (Biermann, 2007), to make sure that trust stays at a high level. The criteria for the dimension of fair governance are therefore: legitimacy, equity, responsiveness and accountability.

These six dimensions form the basis of the analytical tool to find the different levels of adaptive capacity of the Netherlands and Chile while dealing with earthquakes. In figure 2 the adaptive capacity wheel is displayed. With help of different colours or shades, the difference between every criteria and dimension is demonstrated. However, it is important to note that the wheel can never be applied in a completely objective way. The researcher itself will always have to incorporate his or her own interpretation. Therefore, this research is as transparent as possible and every single step is explained. (Van den Brink et al., 2014).

The Adaptive Capacity Wheel has mainly been used in the fields of sustainability, climate change and water planning, for example by Gupta et al. (2015). However, as stated by Van den Brink et al., (2014) the adaptive capacity wheel can be used in several contexts. This can be done by using different or more dimensions and criteria and to make it tailor-fit to the specific context.

Next to that, the display of the wheel is transparent and gives a clear message for the reader of a paper. The use of different colours makes the method very communicative. Therefore, it is very useful for comparison between two or more cases. If a research contains two cases, two different colours in the same dimension make clear that there is lack of expertise in one case and that in this field lesson learning can take place. In the next section, the method of policy learning is explained more deeply.

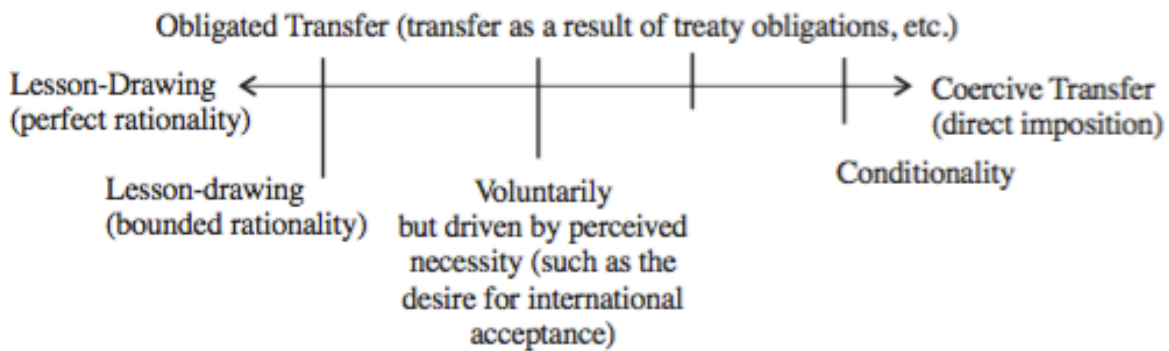
## **2.3 Policy Learning**

As stated before, one of the aims of this research is to increase the understanding of the possibilities of policy learning between two countries while dealing with earthquakes. It is done with help of a comparison between the Netherlands and Chile. This also in an effort to improve the earthquake resilience in the Netherlands. Therefore, the theories on policy transfer and learning will play an important role in this research. Policy transfer or learning refers to the process in which ideas, policies and concepts are transferred between regions or from a different period in time (Dolowitz & Marsh, 1996).

The basis of comparative analysis has been created by Rose (1991). He states that comparison is one of the oldest forms of study in politics and policy and is useful for learning. Studies between different nations are comparative if concepts are applied, so that a certain relation or idea can be tested in different countries. Concepts are essential, because it gives common points of reference to fall back on while doing research. If two countries differ in a certain conceptual attribute, it is interesting to do a comparison and find explanations for the variances in this attribute. Rose (1991) states as well that comparative analysis does not apply extreme universalism. There are many differences between countries while doing comparative research, but it will be also clear that there are boundaries to these differences. These differences are important for the success of the comparison and for the possible transfer of ideas or policies between the countries (Stone, 2012).

The ideas of Rose (1991) form the basis for theory on comparative analysis. However, Dolowitz & Marsh (1996) made more comprehensive use of this idea. They state that there is an explicit difference between 'lesson drawing' and 'policy transfer'. The concept of 'lesson drawing' focuses on political actors that draw lessons from another country and then apply them into their own system. Therefore, 'lesson drawing' is totally 'voluntary' and is based on the choices of the decisions of the local political actors. 'Policy transfer' on the other hand can be voluntary as well as coercive. In this concept a supranational government can oblige a country to apply certain policies. In this research the focus will be on 'voluntary transfer' because the Netherlands can not be coerced by other governments to apply other policies concerning earthquakes.

A voluntary transfer can take place in the country when something not functions well in the system: there is dissatisfaction with the policy or status quo and actors want to change this. When this situation occurs, it is convenient to look over the border of the country and to look for good solutions that already work in another context (Dolowitz & Marsh, 2000)



**FIGURE 3: CONTINUUM OF POLICY TRANSFER LEVELS BETWEEN LESSON-DRAWING AND COERCIVE TRANSFER (DOLOWITZ & MARSH, 2010).**

There are different manners and degrees of policy transfer. Dolowitz & Marsh (2000) make use of a continuum between lesson-drawing and coercive transfer to explain the degree or level of policy transfer. This degree is displayed in figure 3. This continuum can be used to choose how the policy of another country can be implemented. In this research, the situation looks to be in the middle, because Chile can not interfere in the policies of the Netherlands as a supranational government like the European Union or as an economically closely related country. Therefore, the lessons taken from Chile are voluntarily, but also necessary, because of the novelty of the phenomenon of earthquakes in the Netherlands and the inexperience of the authorities.

For executing a policy transfer it is essential to know the limitations of a policy transfer beforehand. This means, that there are some possibilities in which a policy transfer can become unsuccessful (James & Lodge, 2003). Dolowitz & Marsh (2000) distinguish three categories of a transfer that change into a failure.

- First of all, an uninformed transfer, which occurs when actors are not informed well enough when implementing the new policy.
- Secondly, incomplete transfer, which means that the transfer does not contain all the essential components to function well.
- Finally, inappropriate transfer, which means that the new policy does not fit to the contextual environment in the receiving country.

James & Lodge (2003) give critique on these notions. They state that Dolowitz & Marsh (2000) present policy failure as a new sort of transfer but also evoke points of goals of policy actors. However, it becomes clear with the bullet points stated above that there are context problems between countries to be overcome when executing a policy transfer in any degree of form. As stated by Dolowitz & Marsh (2012) in a later paper, their framework is to be used as a heuristic that can be useful for understanding several aspects of the process of policy making and policy transfers. With using it in practice, it could be improved.

Stead (2012) is more clear about the limitations. It is hard to transfer the tacit knowledge and detailed knowledge between different countries, because it is always specific knowledge that functions specifically in the country of origin. Furthermore, tacit knowledge explained in normal and plain language becomes imprecise. Concerning this point, the aim of the research is not

to copy the exact method of Chile into the Netherlands. Therefore, tacit and exact knowledge will not be transferred. The lessons taken from Chile can be used as a basis in the Netherlands to create an own strategy and a tacit knowledge that fits to the context.

Stone (2012) distinguishes in the degrees and methods of policy transfer in another way by using four different terms: Diffusion, transfer, convergence and translation.

- The method of diffusion assumes that ideas spread through so-called osmosis with help of communication networks, geographical proximity, pioneer states and pressure from the national government.
- Transfer on the other hand is more agent focused and makes use of the idea that important actors can mediate in structural forces. Several modalities can be transferred: policy ideas and goals, institutions, administrative tools, ideas and ideologies and personnel. Dolowitz & Marsh (1996) also state that these modalities can be transferred.
- Convergence means that transfer is caused by structural forces, for example by globalisation, countries can get a somewhat equal political and social organisation. This means that a country gets pushed to get along with the majority of countries. In this way the country has a certain amount of path-dependency because of globalisation.
- Translation means that a policy transfer needs to be well 'translated'. In other words, it needs to be made fit to the context of the other country to make it successful. So it can be seen as a method of transferring for example policy ideas, but these ideas need to be made tailor-fit for the other country. The problem with this method of policy transfer is the fact that every context differs per country and that a method should be changed every time.

Because of the translation issue, it is beneficial to find a method in which differences in contexts first can be found and in essence 'switched-off'. In this research this is done in the first place with help of the adaptive capacity wheel, by checking what the differences are in adaptive capacity performance between the Netherlands and Chile while dealing with earthquakes.

To operationalize a possible policy transfer, it is necessary to evaluate the transferability and applicability of this policy with help of a framework. Williams & Dzhekova (2014) give an example of such a framework. With help of this framework the core mechanisms of a donor country can be tested with the contextualizing factors of a receiving country. It has two parts: transferability and applicability. Transferability assesses whether a generalized concept of a possible policy can be applied in a different context. On top of that, it tells whether different problems can be solved with help of the core mechanisms. Applicability tells whether it is possible to also do interventions in the local context to make it possible to implement the policy lessons. This depends for example on the political climate and social acceptability. The framework, with the aspects that are of importance for this research, is displayed in table 1. With help of this framework and the Adaptive Capacity Wheel the conceptual model of the research is created, which is explained in section 2.4.



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**TRANSFERABILITY**

<b>Question criteria</b>	<b>Why important</b>
<b>Does the need exist?</b>	Explains whether in the receiving country it is necessary to make a change, because of the problems caused by a certain phenomenon, in this case the earthquakes in the Netherlands. It therefore makes clear whether policy learning is a useful exercise.
<b>What is the difference in the risk status?</b>	Explains if there are context differences in the levels of risk between the donor and the receiving country. For example, the earthquakes have a lot of different contexts, thus this knowledge should be incorporated to come to a successful policy learning practice.
<b>Prevalence of issue?</b>	Explains whether a phenomenon plays a major role in the local context. It therefore indicates if, the earthquakes in the receiving country affect a lot of people and the level of necessity for a solution.
<b>Policy has same objective?</b>	In this way, it is ruled out that the newly introduced policy will be used for the wrong cause.

**APPLICABILITY**

<b>Political Priority?</b>	Assesses whether the receiving country has enough political will to change their method and to possibly incorporate lessons from other countries.
<b>What is the Impact on other Stakeholders?</b>	Gives an overview of the impact of the hypothetical policy implementation on important stakeholders in the receiving country. For example, what is the impact of the new policy on the gas production stakeholders in the Netherlands?
<b>Other barriers and structural constraints?</b>	Assesses if there are other situations and contextual constraints that can block the implementation of the lessons. For example, the government of Chile is more technocratic than compared to the Dutch government; is that a constrain?

TABLE 1: SHORT VERSION OF FRAMEWORK OF TRANSFERABILITY AND APPLICABILITY, WITH THE CRITERIA THAT ARE USEFUL FOR THIS RESEARCH (BASED ON: WILLIAMS & DZHEKOVA, 2014).

## 2.4 Conceptual model

This section gives an overview of where the theories and concepts are located in the research process. This is done with help of a conceptual model. The conceptual model is necessary for this research to structure the amount of concepts that are used and is used throughout the study. The conceptual model is displayed in figure 4.

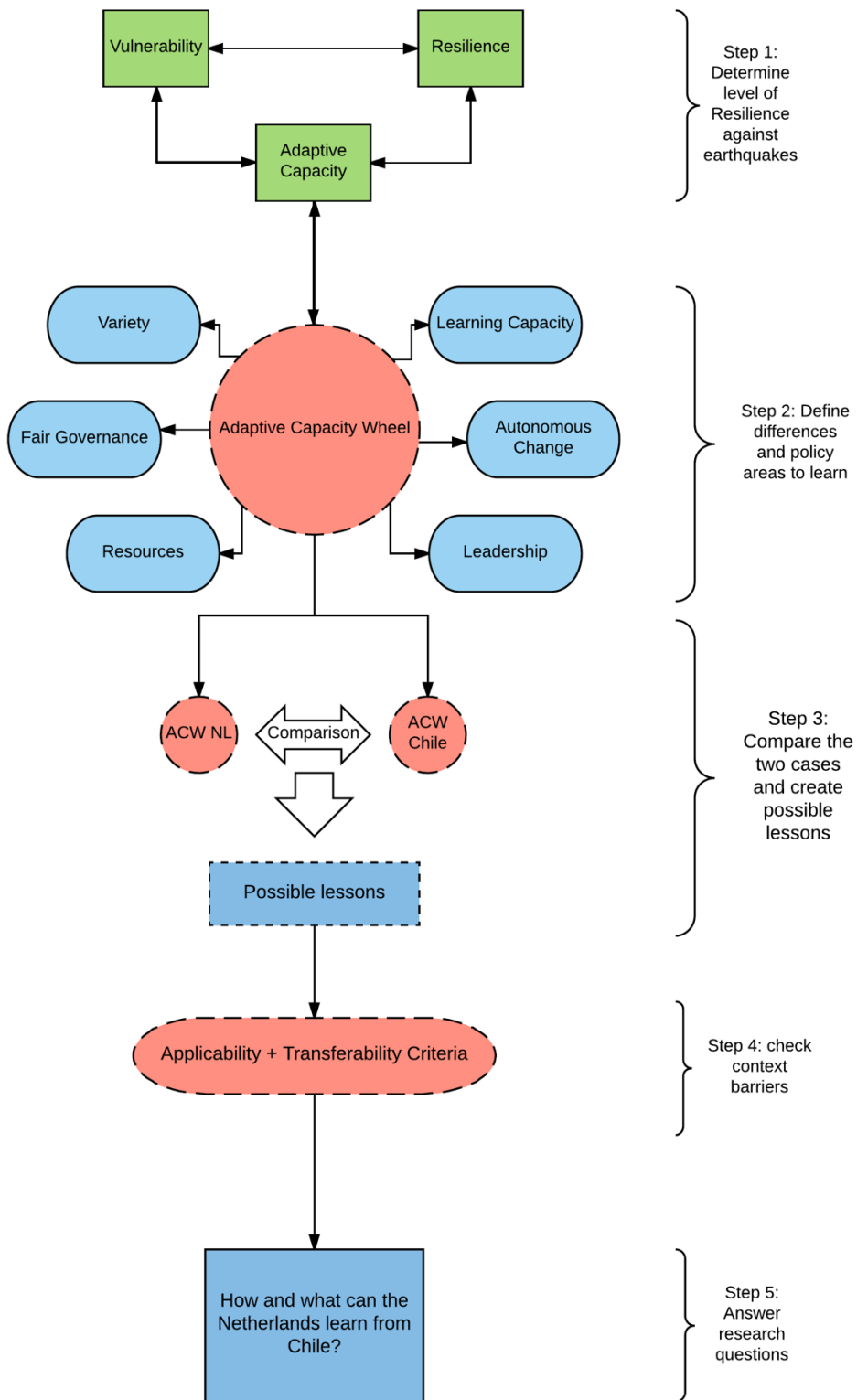


FIGURE 4: THE CONCEPTUAL MODEL OF THE THESIS.

## **2.5 Conclusion**

This chapter has explained the most important theories that form the basis of this research. The chapter started off with explaining the theories of resilience, as we founded the connections between resilience, adaptive capacity and vulnerability.

In the second section the concept of the Adaptive Capacity Wheel has been explained and it will be used to explain the resilience of the two countries. The last section has explained the theories on policy transfer as well. They are important for this research because one of the goals is to let the Netherlands learn from the policies on earthquakes in Chile. The continuum of policy transfer levels plays a vital role in this research. It makes clear that every policy needs to be adapted to the local context to make it possibly successful. This means that a voluntary transfer is the most probable method that can be applied with help of this case study. The next chapter explains how the research is executed on basis of the theories and concepts.

### **3 Methodology: a study of two cases**

In this chapter the methodology of the research is explained. The methodology forms the basis for the research execution because it explains how the research is done. This chapter therefore explains the choice for the research approach, the different data collection methods that are used, how the data is analysed and how has been dealt with the ethics of the research. The next section starts off with the explanation of qualitative research and why it is of use for this research.

#### **3.1 Qualitative Research**

Doing research in social science, geography and planning can have two different paths: using methods for quantitative research is the first one. These methods are originated from physical geography and focus on their concepts and reasoning with help of mathematical modelling and reasoning (Clifford et al., 2010). Methods that are commonly named as 'quantitative' are for example questionnaires and research with help of maps and data sets (Bryman, 2006). However, some geographers have critique on this method, because it would be a too positivist approach in which the reality is partly excluded when researching policy interventions. They state that it is more important to focus on behaviour, opinions and ideas, because human behaviour is subjective and complex or make use of a combination of these ideas and quantitative research (Clifford et al., 2010).

Therefore, the other path is of importance: methods for qualitative research. These methods focus more on the behaviour of people. They question why people take certain decisions and examine different relations, social processes and the influences of power within a geographical unit. Qualitative research in the human context has as a goal to understand very complex interrelationships (Stake, 1995). Examples of methods with a qualitative character are in-depth interviews, participant observations and focus groups (Clifford et al., 2010; Bryman, 2006).

Since this research focuses on policy making in dealing with earthquakes, it is preferable to work with mostly qualitative methods, backed with a few quantitative facts and figures. With help of interviews and document analysis the choices of policy makers in Chile and the Netherlands is unravelled to reveal the reasons behind those choices and to make a comparison between the two countries. With help of a case study research of two different cases this is done.

#### **3.2 Case Study Research**

This research makes use of a case study research in two different regions that have a context in which they have to deal with earthquake hazards. This is done because comparative analysis means that two countries or regions are examined as two parallel independent cases (Rose, 1991). The method of case study is useful in this research because several sources, qualitative as well as quantitative, can be used in a relatively detailed sense (Yin, 2003) to get a clear view on the situations and policy choices in the regions. A case study focuses on the unique and explains why a certain case stands alone in its situation (Simons, 2009). On top of that, it can explain the complexity of a case, by understanding the different circumstances it occurs in. The goal is to maximize what a researcher can learn from one certain case and in this way to fully understand it, so that the information can be used to increase knowledge about

a certain subject (Flyvbjerg, 2006). The researcher focuses on trying to understand the different views and actions of different stakeholders to explain why the state of a case is as it is (Stake, 1995). In this research the focus will be the same while executing the case study.

Choosing a case for qualitative research depends on less characteristics than while doing quantitative research. This is because qualitative research is not about sampling, but, as stated before, about understanding a certain case. The most important conditions are, in the first place, time and possibilities for fieldwork. It should be possible for a researcher to do his work, caused by proximity to the location and having the resources to execute the research. Secondly, a case study should incorporate the main characteristic in which the researcher is interested in (Stake, 1995). In this research the two cases have the characteristic that they are subject to earthquake hazards and therefore are of interest for comparison.

A case study of two cases on the two different countries is done, to find out what the level of resilience against earthquakes in both countries is. On top of that, the context barriers are exposed to make clear whether a transfer is possible. With help of semi-structured interviews with Dutch stakeholders and researchers, questionnaire interviews per e-mail with Chilean researchers and literature reviews of policy documents and earlier research on earthquakes a complete view will be created on the policy thinking of the countries. In Appendices 2 and 3 an overview is given of the different interviewees and used documents for reviewing.

### **3.3 Units of analyses**

The unit of analysis, or the case, is determined by defining spatial boundary, theoretical scope, and timeframe (Yin, 2003). Therefore, the cases need to be clearly defined, also to prevent vagueness.

The definition of the area of research in the Netherlands is clear, because the earthquakes take place in one particular region: the province of Groningen. However, also national actors play an important role, because they are responsible for the extraction of gas and therefore for the inducement of earthquakes. The case will therefore be focusing on two parts: the handling of earthquakes in the province itself and how the national government acts when dealing with the occurring problems.

The area of research in Chile is a bit different because of two reasons. Firstly, earthquakes are in this country possible in every single region because of its geological origin (Rhea et al., 2010). Therefore, the role of the national government is much more important. Secondly, because of research technical reasons, it will be hard to do research on location in Chile. The research focuses on policy documents and earlier research for creating a view on the situation in Chile. On top of that, two researchers give an insight into the several methods of the authorities and citizens of Chile. The research focuses on the role of the national government in Chile and examples of local and regional governments. This will help to compare it in the first place with the handling of the national government in the Netherlands, and secondly to compare the local and regional governments of the two countries.

The input from these cases is explained with help of several theories. As explained in chapter 2, the theoretical scope is on adaptive capacity, resilience and policy transfer and learning. It therefore mostly focuses on the institutional roles in the two countries. This is because the aim of the research is to improve the policy on earthquakes in the Netherlands.

### **3.4 Data Collection Methods**

This research focuses on retrieving the different reasons behind actions of local actors in dealing with earthquakes. Two methods are used for the research on the two countries. With help of document analysis and two on paper interviews a view will be created on the situation in Chile. In the Netherlands two methods are used: document analysis and in-depth interviews. The list of interviewees is displayed in Appendix 2 and a list of used documents is displayed in Appendix 3.

#### **3.4.1 Semi-structured interviews**

In-depth interviews are useful when the research is focused on the views of other people. The root of in-depth interviewing lies in the understanding of a situation by other people and which meaning they give to that understanding. The interviewer wants to retrieve these ideas of other people and then give his or her own meaning to it (Seidman, 2006). As stated by Gill et al. (2008), there are three types of in-depth interviewing: Unstructured, structured and semi-structured.

Unstructured interviews start with an opening question and develop randomly without using a list of questions. Structured interviews are the opposite. In essence, they are verbally made questionnaires because there is not a lot of flexibility while executing the interview. A structured interview does not defer from the question list at all. Semi-structured interviews consist of a few key questions, alongside the interview is taking place. However, it allows to give more detailed explanations of certain ideas or areas by the interviewee. It gives guidance to the interviewer, but it also creates more flexibility than structured interviews. Interviewees have a lot of room to explain their actions in-depth and that will be of extra worth for the research than sticking to one standard question list. Because this research focuses on the reasons of actions by actors and the possibilities of policy transfer, semi-structured interviews are the method that is used to retrieve the views, motivations and experiences of policy actors in the Netherlands (Gill et al., 2008).

For executing semi-structured interviews an interview schedule is necessary to address the goals and to answer the questions of the research (Gill et al., 2008). This interview schedule is displayed in appendix 1 including the coding list used for the analysis. Appendix 2 contains the list of interviewees that have responded. This appendix explains why, when and where the interviews have taken place. The transcriptions and recordings of the interviews can be requested via the researcher. Appendix 4 contains the English translation of the Chilean interviews.

#### **3.4.2 Document review**

Document analysis is the second method of research. This method is a systematic procedure for evaluating and reviewing documented material and is often used as a method for triangulation (Bowen, 2009; Bryman, 2006). The research part in the Netherlands contains semi-structured interviews as well as a thorough document analysis to ensure this triangulation. The case of Chile is done with help of document analysis and two structured e-mail interviews with two Chilean experts. Bowen (2009) states four reasons why document analysis can be of use during researching. All four reasons are of importance during this research.

- Firstly, documents give historical insight and a lot of background information.
- Secondly, the information from policy documents can inspire to create new interview questions. For example, in this research the ideas from the policy documents about the case of Chile can give new insights and contributions during an interview.
- Thirdly, documents make it possible to track changes and development of a case or actor.
- Finally, with help of documents it is possible to verify statements or events from other sources.

Doing this document analysis must be done in a structured way (Clifford et al., 2010). The analysis of documents involves three different stages of reading, namely superficial examination, reading and interpretation. During the reading part it is essential to organize information into categories. This can be done with help of coding (Bowen, 2009). Appendix 3 contains a list of documents that have been used during this research and explains why they are important and how they have been used.

### **3.5 Data Analysis**

Coding is important for the analysis of the interviews as well as the documents. Codes make clear what is important for the research and make sure that the analysis is done in a structured way (Clifford et al., 2010). The codes to analyse the documents and the interviews can be the same, because the documents are supplementary to the interviews and it is easier in this way to integrate the two data sources (Bowen, 2009).

Therefore, a coding list is created. Because the Adaptive Capacity Wheel (Gupta et al., 2010) and the concept on Cross-National Transferability (Williams & Dzhekova, 2014) are used as a framework for analysis, the codes consist of the main parts of these two concepts. A short overview is given in appendix 1.

To understand the whole process of for example the interviews and the reading of documents, an overview has been made of the research strategy. This is displayed in table 2.

<b>Period</b>	<b>Research Activity</b>
<b>December 2016</b>	Brainstorming sessions during stay in Chile, with help of news articles and own experiences. An event of an earthquake did not create a large stir in the country. It becomes clear that there is a large difference between the Netherlands and Chile.
<b>January 2017</b>	Find literature to create a research framework. This forms the basis of the literature and methodology chapters
<b>January 2017</b>	Selection of policy documents per country to form a basic view of the situation in both countries.
<b>February 2017</b>	Selection of interviewees in the Netherlands to form in-depth views of the situation in that country. The interviewees should either be one of the actors that knows a lot of the situation or is an expert on earthquakes and on how to deal with them.
<b>February 2017</b>	Selection of Chilean Interviewees that are experts on the mechanism of earthquakes and on how the government prepares and acts for them
<b>February 2017</b>	Create in-depth interview questions for semi-structures interview sessions, partly on basis of the policy documents and on the concept of the Adaptive Capacity Wheel. On top of that, create a list of codes to analyse the interviews as well the policy documents in an in-depth and structured way.
<b>March &amp; April 2017</b>	Execute interviews on location, on telephone or, in case of a Chilean interviewee, with help of a question list. Directly after the interview, transcribe the recording so that non-verbal communication can be incorporated as well
<b>April 2017</b>	Analyse interviews and policy documents with help of the codes based on the concept of the Adaptive Capacity Wheel
<b>May 2017</b>	On basis of the analyses, fill in the Adaptive Capacity Wheels. This consists of writing the results chapter. On top of that, make notes on the several best practice methods of Chile that possibly can help in the Netherlands
<b>May 2017</b>	With help of a comparison between the two Adaptive Capacity Wheels, define the areas in which the Netherlands can learn from Chile.
<b>June 2017</b>	Write on basis of your findings the conclusion and discussion
<b>July 2017</b>	Rewrite thesis and hand-in when it is finished.

TABLE 2: RESEARCH STRATEGY

### 3.6. Research Ethics

To keep the information retrieved from actors and other sources reliable, it is important to keep an eye on the ethics as a researcher. It will ensure that the understanding from research participants is better (Hennink et al., 2010).

Stake (1995) gives a number of aspects of research ethics that should be incorporated while executing the study. This mainly focuses on the interviews. Researchers must explain before an interview why an organization or interviewee has been chosen and what the prospects are of the study. Next to that, it is of importance that the interviewee is asked if he or she would like to change something in the interview or in the transcript after it has been made. Finally, privacy should be the highest priority. If, for example the interviewee would like to be anonymized. All these ideas have been applied during this research. Interviewees have been asked beforehand if they allow that their interview is recorded and all interviewees have made clear that it is no problem that their name is used for this research.



### **3.7 Summary**

This chapter has explained the methods that are used for executing the research. Interviews and the review of important documents are forming the basis of the research. The analysis is done with help of codes based on the Adaptive Capacity Wheel (Gupta et al., 2010) and the Applicability and Transferability Framework (Williams & Dzhekova, 2014). The results from this analysis are explained in chapter 5. The next chapter explains the mechanisms of induced and natural earthquakes and how the different scales of measuring work. This chapter is of importance to understand the context differences between the two cases.

## 4 Context: the mechanisms of earthquakes

In this research a comparison is made between two different regions to create lessons for improving resilience against earthquakes. However, the causes and therefore the nature of the earthquakes differ in both regions. In the region of Chile earthquakes have a natural cause and the causes of earthquakes in Groningen are anthropological. Therefore, the nature of both earthquake situations need to be explained so that the context differences of the causes and effects are clear.

This chapter does this, by explaining the mechanisms of both sorts of earthquakes on basis of what the research knows, how earthquakes are measured and what the differences are between man-induced and natural earthquakes.

### 4.1 Measuring intensity

The severity of an earthquake can be measured with different methods and this section explains the commonly used ones. The first and most common method is the Scale of Richter. This scale has been used until 1979 to display the severity of an earthquake and was invented by seismologists Richter and Gutenberg in 1935. On basis of the highest amplitude, also called the Peak Ground Acceleration (PGA) and the frequency of the vibration, the power of the earthquake is determined on a logarithmic scale. The downside of this scale is that it is impossible to measure more intense earthquakes above 7.0 on the scale of Richter (Lay & Wallace, 1995).

That is why in 1979 the Moment Magnitude Scale has been invented, which also can measure the severity above 7.0 on the scale of Richter, annotated as  $M^w$  (Hanks & Kanamori, 1979). This scale is made on basis of  $M^0$  or the Moment Magnitude, which is determined with help of the shear modulus or the shear stress of the rocks that are involved during an earthquake event, the total area of rupture alongside the fault and the average displacement of the earth caused by the vibration. With help of  $M^0$  it is determined how high an earthquake event should be placed on a logarithmic scale. This Moment Magnitude Scale is since 1979 the most commonly used scale for displaying what the severity is of an earthquake (Lay & Wallace, 1995; Hanks & Kanamori, 1979).

The third scale explains the severity in a different way, on basis of the perception of people and the damage observed on for example houses and infrastructure. This scale is called the Mercalli Intensity Scale and is spread out between intensity levels of I and XII. An earthquake with an intensity of I is not felt. An earthquake with an intensity of XII however, has extreme catastrophic power. This scale is more useful for local authorities, because  $M_w$  does not always explain the damage a region endures. This is because the intensity depends on more factors, for example shallowness and soil type (Lay & Wallace, 1995). A comparison between the two scales is displayed in table 3.

<b>Moment Magnitude Scales</b>	<b>Typical Maximum Modified Mercalli Intensity</b>
<b>1,0-3,0</b>	I
<b>3,0-3,9</b>	II-III
<b>4,0-4,9</b>	IV-V
<b>5,0-5,9</b>	VI-VII
<b>6,0-6,9</b>	VII-IX
<b>7,0 or higher</b>	VIII or higher

**TABLE 2: COMPARISON OF THE MOMENT MAGNITUDE AND MERCALLI SCALES.**

The final measuring method that is of importance for this research is the Peak Ground Acceleration, or PGA, already mentioned in the beginning of this chapter. It is an important method of measurement in the research to induced earthquakes in Groningen. On basis of the PGA is decided which houses are in the earthquake area and which are not (Spetzler & Dost, 2016).

It is important to note though that media, that are covering the news on earthquakes in Groningen, are often using the scale of Richter to explain the power or intensity of an earthquake (For example: Van den Berg, 2015b; Amin, 2015). It can be misleading in two different ways. Firstly, it does not explain the situation well enough to have a grasp on the real impact of an earthquake. Secondly, the scale of Richter is not the common used method for measuring the magnitude of earthquakes.

## **4.2 Natural earthquakes in Chile**

Earthquakes with a natural cause do not occur on random places on the earth surface. The outer layer of the earth, 70 km thick, consists of several plates that are moving towards, alongside or apart from each other. Earthquakes take place mostly where these plates meet. In essence, there are three different sorts of zones. Firstly, spreading zones, where two plates spread from each other, caused by rising molten rock. Earthquakes here are in most cases relatively small in magnitude, but in shallow depth. Secondly, transform faults are locations where two plates are sliding alongside each other. And finally, subduction zones where one plate slides underneath another plate (Shedlock & Pakiser, 1994). At these locations the majority of the largest earthquakes take place (Stein & Klosko, 2002). An example of this situation is found at the Peru-Chile trench, where the Nazca plate is subducting under the overriding South-American plate. During this research the focus is on this area because this is the fault zone that causes the major earthquakes in Chile (Rhea et al., 2010). In figure 5 the location of the country is displayed.

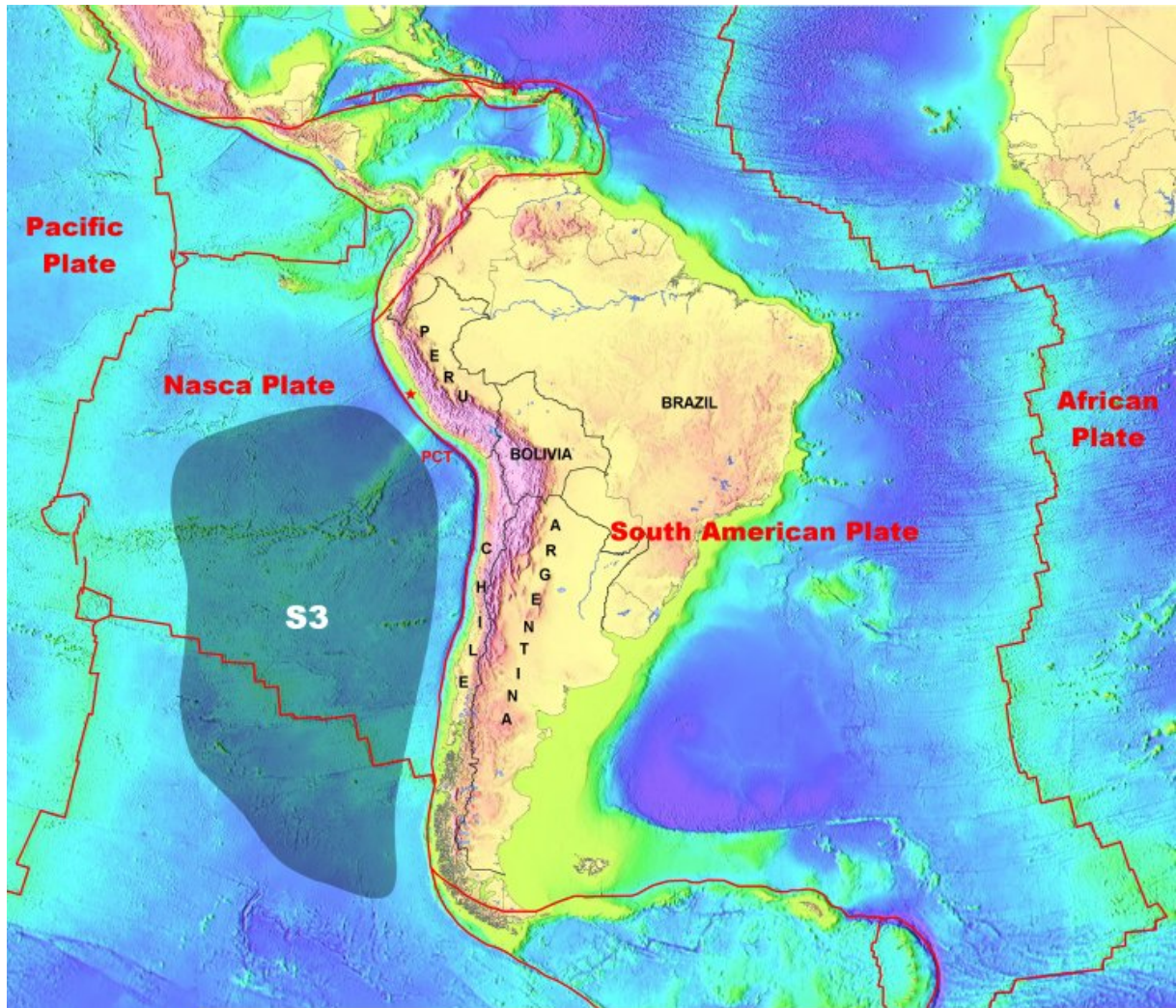
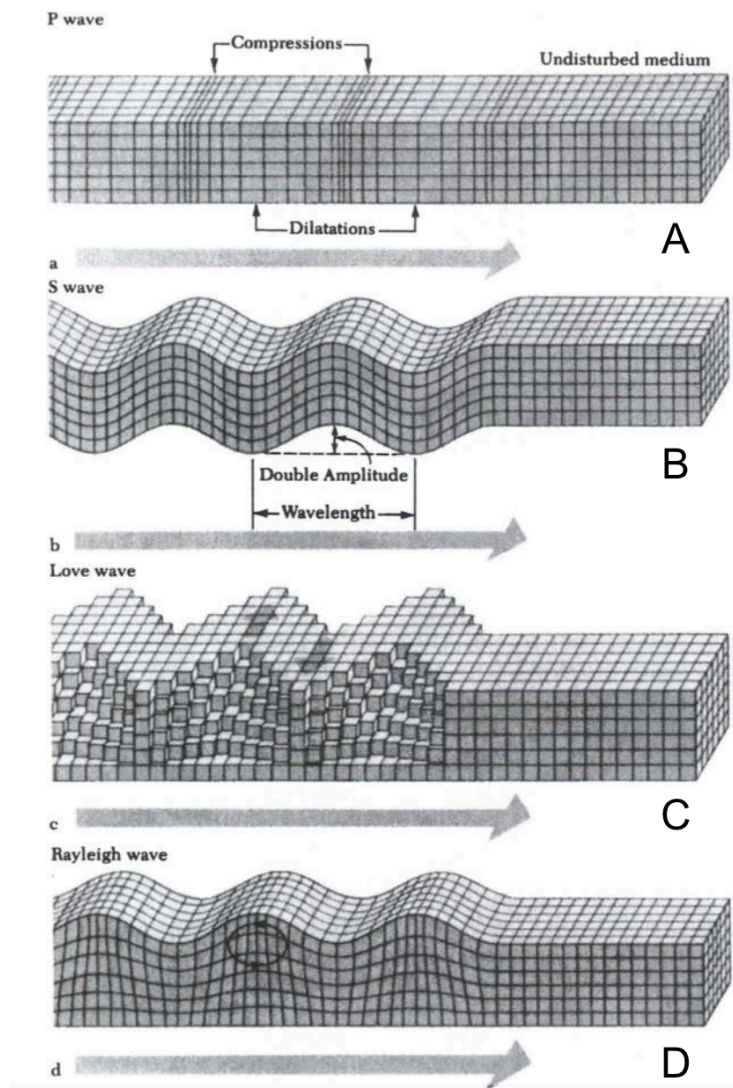


FIGURE 5: OVERVIEW OF THE LOCATION OF CHILE, CIRCLED BY THE NAZCA AND SOUTH-AMERICAN PLATE (HUTTENCOMMENTARIES.COM, 2017).

There are three different sorts of faulting mechanisms that are all connected to one sort of fault zone. Firstly, normal faulting, which takes place at spreading zones. The overlying block goes down towards the underlying block, or into the dip of the fault plane. This happens in response to tension or pulling. The second, strike-slip fault, happens at transform faults. Stress here is caused by pulling or by compression and squeezing. The final one is thrust, or reverse, faults. These take place at subduction zones. Earthquakes are here caused by squeezing or compression (Shedlock & Pakiser, 1994).

If the compression or squeezing stress of a plate becomes higher than the strength of the rock, it will snap and break into a new position. This creates several vibrations, also called seismic waves. There are two different sorts of waves, which are displayed in figure 6: body waves (A+B) and surface waves (C+D). Body waves consist of two different sorts. *Compressional body waves* travel at great speeds and can also travel through the earth's molten core. Because of their speed, they are called "primary" or P-waves (A). These waves just move right in front or right behind the line of travel. *Shear body waves* however do not travel through the molten core and reach the earth surface later than P-waves. That is why they are also called secondary or S-waves (B). These waves displace earth material in a 90-degree angle on their

line of travel. The difference between these two sorts of waves are important. A small first thud, which is the arrival of P-waves, can indicate that an earthquake will take place (Shedlock & Pakiser, 1994; Stein & Klosko, 2002). At the surface of the earth, the interaction of P- and S-waves (A+B) with the boundary conditions of the surface cause the second sort of waves: the surface waves (C+D). These waves have two sorts: Rayleigh (D) and Love waves (C), which both propagate alongside the surface of the earth (Thorne & Terry, 1995). The difference in these two sorts lies in the way of propagation. Rayleigh waves have as characteristic that they move in an elliptical motion. Love waves though vibrate in a perpendicular motion. The surface waves have the most power and cause majorly the severe damage above the surface (Thorne & Terry, 1995).



**FIGURE 6: THE FOUR DIFFERENT SEISMIC WAVES THAT CAUSE EARTHQUAKES. THE INTERACTION OF P- AND S- WAVES (A+B) CAUSES THE THE EMERGENCE OF LOVE AND RAYLEIGH WAVES (C+D) (LAY & WALLACE, 1995).**

The severity of an earthquake depends on a couple of things. Firstly, how deep the source of an earthquake is located. If the source is deeper, than the power of an earthquake at surface of the earth becomes less. Secondly, the material through which the waves of the earthquake

travel. For example, as stated by De Bruijn (3 April 2017) in its interview “a rock surface is less favourable than a softer surface.” On the other hand, an unstable surface, like for example clay is less favourable than a stable ground like granite (Shedlock & Pakiser, 1994).

### 4.3 Induced earthquakes in Groningen

Induced earthquakes are a non-natural phenomenon because they are man-made. There are different causes of induced earthquakes:

- Firstly, hydraulic fracking. With this method gas is extracted with help of injecting water.
- Secondly, oil extraction and the disposal of wastewater.
- Thirdly, the extraction of gas from the earth.

All of this human activities cause that there is a change in pressure in the soil of the earth. This change in pressure causes that an existing fault can fail, with as a consequence that an earthquake is created. Most of these earthquakes are micro-earthquakes (around 2.0 Mw), but some of them can be stronger (Ellsworth, 2013).

An important notice on the induced earthquakes in Groningen is that they are not caused by injection of a fluid, but by the extraction of gas. As stated by Van Eck et al. (2006) earthquakes in Groningen are caused by the difference in porous pressure, and not by the difference in pressure near faults that would cause extra fault instability. However, in more recent sources this statement has been proven not completely valid. As stated by Van Thienen-Visser & Breunese (2015) & TNO (2014) there is a relationship between the compaction of the earth caused by pressure differences and extra stress near fault lines. On top of that, it has been found that compaction and the seismic moment are interrelated into each other within an exponential function (Bourne et al., 2014). Therefore, the pressure changes caused by gas extraction are a direct cause of seismic movement near the faults in the Groningen gas field. Also the subsidence of the surface is a direct consequence of the gas extraction (Van Thienen-Visser & Breunese, 2015; TNO, 2014).

What makes it difficult to be sure about the causes and the effects of the earthquakes is that there is a lot of uncertainty and therefore a necessity for more research. TNO (2014) states that it is necessary to invest more effort in researching the region and to evolve better models for calculations. What also is not clear yet is which sort of seismic waves are caused by induced earthquakes and how energy propagates through the ground. More research is necessary to create a good understanding on how the surface of the earth in Groningen moves and energy of the ground motion propagates (De Bruijn et al., 2016). However, uncertainty will always play a vital role in regions affected by earthquakes, something that authorities will need to deal with to increase the resilience of the region (Berkes, 2007; Interview de Bruijn).

## 4.4 Comparison

This chapter has explained the different causes of earthquakes, natural and man-made in a short overview. This to display the differences in situations between Chile and the Netherlands. These context differences are of high importance to test whether policies and ideas from Chile could work in the Netherlands. The differences are displayed in table 4, on basis of the last major event in Chile, the earthquake in 2010, and the longer period of earthquakes in the Netherlands from 2012.

	<b>Chile</b>	<b>the Netherlands</b>
<b>Sort of earthquake</b>	Natural	Man-made
<b>Highest recorded moment magnitude</b>	8,8 Mw (Maule region)	3,6 Mw (Huizinge, 2012)
<b>Highest recorded intensity</b>	XI (different regions)	VI (Huizinge, 2012)
<b>Average shallowness</b>	10-60 km deep	1-3 km deep
<b>Soil</b>	Rock/granite	Sand, Clay, Peat or a combination.
<b>Tsunami Risk</b>	High	Non-existing
<b>Risk of deaths</b>	High	Low
<i>Comparison events</i>	<b>Maule Earthquake (2010)</b>	<b>Groningen earthquakes</b>
<b>People affected by (% of total population country)</b>	12.8 million people (75%)	~100,000 (0,6%)
<b>Victims last major event</b>	524	~0
<b>Houses in affected area</b>	220,000	22,000
<b>Housing reconstruction costs</b>	2.5 billion dollars	Not clear yet

TABLE 3: COMPARISON OF THE 2010 CHILEAN EARTHQUAKE SITUATION AND THE EARTHQUAKES IN THE REGION OF GRONINGEN (LIZAMA, 2011; MINVU, 2011; TNO, 2014; NCG, 2014; EKKER, 2016).

The most important conclusions from table 4 are the following. Firstly, the earthquakes in the Netherlands are man-made, so there is also an actor that causes them. So in this case, there is someone 'guilty' and can be prosecuted (Amin, 2015). In Chile, there is no 'guilty' actor. On the contrary, the earthquakes can be seen as a phenomenon that is part of daily life in Chile. Because of that, the government feels directly responsible for the victims (Useem, 2015). Secondly, the earthquakes in Chile are much stronger and therefore more destructive. On top of that, the earthquakes in Chile can cause tsunami waves, which have been responsible for the most deaths during earthquake events in that region, for example during the 2010 event (Carroll, 2010). However, the earthquakes in the Netherlands are really shallow in comparison to the natural earthquakes: maximum 3 km deep compared to a minimum of shallowness of 10 kilometre deep. So, however the earthquakes in Groningen are less strong, they still can cause a lot of damage. Thirdly, there is a difference in the soil between the two regions. However, there is not enough research done on what is positive or not positive in this sense. Respondents in the interviews of this research could also not give a conclusive answer on this topic. And finally, the comparison of the amount of people and houses affected makes clear that the urgency for the Chilean national government is also much higher, because a lot more people are involved in the disaster caused by earthquakes (MINVU, 2011; Ekker, 2016). These context differences of the causes of earthquakes play a vital role in the comparison and the possible creation of lessons during the rest of research.

## 5 Results: two countries with two different approaches

In this chapter the different results from the research are presented. These results are found, as described in chapter 3, in the literature, policy documents and with help of interviews with different actors and experts in the Netherlands and in Chile. The goal is to reveal the methods for having resilience against earthquakes in both countries so that they can be compared. The next step is to reveal possible lessons from Chile that can be applied in the Netherlands. The chapter starts off with the results of the research of the two cases, Chile and the Netherlands. These are explained alongside the concept of the Adaptive Capacity Wheel, so that filling in the wheel for the comparison is an easy task. As displayed in figure 7, this is the second step in the conceptual model of this research. The third section compares the two wheels and explains from which area the Netherlands can learn from Chile and which methods are possibly useful for increasing the resilience against earthquakes.

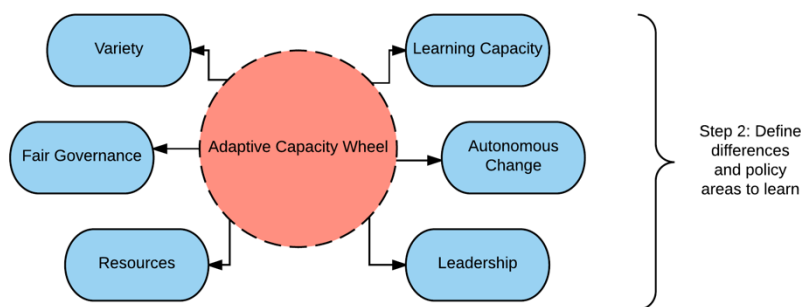
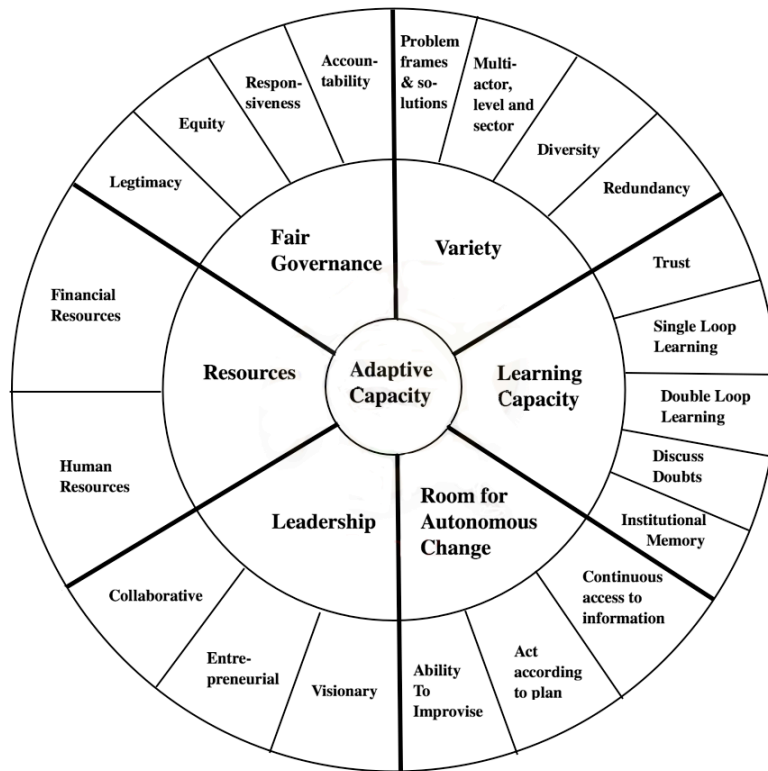


FIGURE 7: THE SECOND STEP OF THE CONCEPTUAL MODEL: FILLING IN THE ADAPTIVE CAPACITY WHEELS.

### 5.1 Adaptive Capacity Wheel of Chile

To start off the result section, the case of Chile is explained and analysed with help of the Adaptive Capacity Wheel. Because this is an important tool during this research, the wheel is again displayed in figure 8. The upcoming section is divided per dimension. The first one is for example Variety. The goal is to reveal in which areas Chile is strong or weak in the handling of earthquakes so that the level of adaptive capacity can be determined.





**FIGURE 8: THE ADAPTIVE CAPACITY WHEEL USED FOR THIS RESEARCH (BASED ON: GUPTA ET AL., 2010).**

### 5.1.1 Variety

Chile has as main goal to secure the safety of the citizens as much as possible. The focus in Chile is on technical solutions to maximize the safety of the citizens. The most important measure in this case are the building codes and standards for the construction of housing and other buildings. They are legally defined, which means that construction companies need to apply these standards, to prevent the risk of legal consequences. Buildings are checked regularly, to check whether buildings are still safe (Useem et al., 2015; ONEMI, 2016). Because of the long history of earthquakes, the authorities in Chile have a lot of knowledge on what quality of construction is necessary for the building standards. Authorities and citizens have a high trust in these building standards, which makes them feel safe (Interview Bakema).

Citizens are in several ways informed by how they can prepare for a disaster. The first method are the tsunami alerts and evacuation routes, which is guided by the program *Chile Preparado*. After the 2010 earthquake in Maule this program has been installed and evacuation routes and tsunami alerts have been improved and made more efficient, also with help of drills and exercises on how to behave during an earthquake and a possible tsunami. These drills are done every two years in every coastal town, so that people exercise where they need to go and what they need to do during a real earthquake (Interview Santibañez; ONEMI, 2016; Useem et al., 2015). The same counts for large apartment buildings, in which signs explain on how to behave during an earthquake event and drills are done every year (Interview Bakema). On top of that, there are special programs for students, scholars and workers on how to prepare, organized by the ministry of education and the ministry of work (Interview Santibañez).

The reconstruction of housing after an event is done in several ways. The first method focuses on insurance. The majority of the housing market is insured for earthquake damage. Private companies for that case are financing a major part of the reconstruction of the country (Useem et al., 2015; MINVU, 2011). Secondly, the reconstruction of housing is partly done with use of subsidies. An example is the aftermath of the earthquake in 2010. People, that had been victim to the earthquake, could apply for a subsidy to reconstruct their house. This subsidy only would be granted if there was enough proof that their house was demolished or damaged by the earthquake. Government officials were sent out to ensure that people needed a subsidy. With help of this financing, Chilean citizens could choose their own constructor for their housing. Two years after the earthquake, 220,000 subsidies were applied (MINVU, 2011; Platt, 2012).

Preparing for earthquakes in Chile focuses for the major part on emergency management for when an earthquake occurs and less on man-made or natural solutions to mitigate earthquakes and especially tsunamis (ONEMI, 2016; PNUD, 2011b). However, there are a few positive examples that have started since the earthquake disaster in 2010. The national strategic plan to reduce the risks of disasters focuses as well on reducing poverty and increasing liveability with city projects (ONEMI, 2016). An example of this are the newly build houses in the city of Constitución, which are half houses that can be finished by the people that live in it. This form of social housing gives hopes to people that lived in poverty before the disaster and now can create a new life. On top of that, the city has created a natural barrier with help of a coastal forest that will mitigate a new tsunami plus it has created a new public area for the city, which has improved the liveability in the city majorly (Long, 2015). This is an example of a resilient city: not solely reconstruct the original situation, but seeing the disaster as an opportunity to improve (Davoudi, 2012). However, there are differences between regions in Chile, which does not make every city and region resilient for earthquakes in the same way (Interview Jaime Díaz). One of the main causes of this is the neo-liberal context of country, in which the market plays a more vital role than the state, which causes differences per region (Gonzalez-Muzzio & Henriquez, 2016; interview Bakema).

Elaborating on the last two statements, the state in Chile has a very centralized method of operating. The majority of decisions are taken by the central state in Santiago, the capital of the country, and other actors, like lower governments and citizens are obeyed to these decisions (interview Bakema; Interview Santibañez; Romero & Albernoz, 2016). During the reconstruction after the 2010 earthquake the government tried to implement a broader approach with an increased role for the municipalities and regional governments (MINVU, 2011). There are several positive examples that have used this extra possibility, for example the earlier mentioned plan of Constitución (Long, 2015) and the influence of local business and citizens on the new master plan of Concepción (Platt & So, 2016; Gonzalez-Muzzio & Henriquez, 2016). However, the situation in most regions of Chile is that municipalities need to conform to national decisions and that local citizens and authorities barely have influence on decision-making processes (Herrmann Lunecke, 2015; Romero & Albernoz, 2016).

### **5.1.2 Learning Capacity**

An important cause of the level of resilience of Chile is that they have a long lasting experience with earthquake hazards. Table 5 gives an overview of the major earthquake events that have occurred in Chile since 1900. All these earthquakes have been turning points in the method of dealing with earthquakes or have proven that Chile has a resilient method. Therefore, they

have increased the quality of the institutional memory of the country on how to handle with earthquake events. On top of that, it has created a mind-set within the people of Chile that earthquakes are unavoidable and that they have to deal with it (ONEMI, 2016; Interview Díaz). This improves the mental and community resilience of regions in Chile (González-Muzzio, 2010).

Date	Magnitude (Mw)	Maximal Intensity (Mercalli)	Location	Depth (km)	Victims	Tsunami?	Financial Damage (\$)
24 <sup>th</sup> of January 1939	8,3	XI	Chillan	60	30000	No	-
22 <sup>nd</sup> of May 1960	9,5	XI	Valdivia	-	5700	Destructive Tsunami	500 million
3 <sup>rd</sup> of March 1985	8,0	XI	Algarrobo	33	178	Tsunami	-
27 <sup>th</sup> of February 2010	8,8	IX	Central Chile	30	525	Destructive Tsunami	3,6-4 billion
16 <sup>th</sup> of September 2015	8,3	VIII	Coquimbo	11	15	Destructive Tsunami	600-900 million

TABLE 4: OVERVIEW OF THE MOST IMPORTANT EARTHQUAKES THAT HAVE OCCURRED IN CHILE (NOAA, 2017; CSN, 2017; LA TERCERA, 2017).

The ‘construction’ of this institutional memory is thus based on the double loop learning occasions caused by major destructive earthquakes. After the 1939 earthquake for example the building codes were introduced in the Chilean law and have evolved ever since after each event (ONEMI, 2016). Another example is the National Policy for Disaster Risk Management that has been enacted after the 2010 earthquake, to give institutions more strength and to improve emergency and warning systems.

Another factor that improves institutional memory is done by the citizens of Chile. Santibañez states in his interview that knowledge on earthquakes is passed on per generation: *“La transferencia de experiencias dentro de las familias, para los últimos terremotos las personas expresan que los conocimientos de prevención fueron adquiridas en el núcleo familiar.”*

To keep the current knowledge level high, the government of Chile keeps emphasizing on training the earthquake drills and on education and awareness campaigns. In this way they make their method as efficient as possible (ONEMI, 2016; Interview Santibañez; Interview Díaz). Therefore, the emergency response of the authorities and the evacuation during the 2010 Maule earthquake for example was quick and smooth (Platt & So, 2016).

However, caused by the fact that the political system of Chile is very centralized, there is also a negative side to the coin. The national government knows everything certain and chooses for their own method, which does not contain a lot of reflection nor can it be influenced by other actors, like lower governments and private companies (Interview Díaz; Interview Bakema). Nonetheless, this again differs per area. Plans that were made in the city Concepción in the Bío-Bío region for example were made together with other actors, like citizens and local business in focus groups and face-to-face meetings (Platt & So, 2016; Gonzalez-Muzzio & Henriquez, 2016).

Trust plays an important factor in the risk perception of local citizens. As stated by Bronfman et al. (2016) citizens feel less safe when they do not trust the capabilities of local authorities or experts and decides whether people are open enough for learning and want to take personal measures (Gupta et al., 2010). The level of trust in the several authorities in Chile differ. In a research by Bronfman et al. (2016) it becomes clear that the level of trust in the emergency authorities, for example the Red Cross and the Fire Brigade is high. The trust in the authorities that should prepare mitigation measures, namely the national government and ONEMI, is very low. This is caused by their performance during the 2010 earthquake which was criticized heavily by the media and the Chilean citizens (Bronfman, 2016; Sandoval & Voss, 2016). On top of that, the overall trust in the government authorities is not high, caused by corruption casualties (Garate-Neidhardt, 2015; Interview Bakema).

### **5.1.3 Room for autonomous change**

One of the main strategies of Chile is providing information in different ways. Since the earthquake of 2010 the provision of information has majorly been improved. This is done with help of the earlier mentioned National Policy for Disaster Risk Management and the National System of Risk and Emergency Management. Early warning and monitoring systems have been improved in this way (Bronfman et al., 2016; ONEMI, 2016). The monitoring of earthquakes is done by the National Seismologic Centre. The information of every earthquake that occurs is available to everyone (CSN, 2017). In this way the Chilean people can see themselves where they are at risk and if they need to take measures.

Other ways of information provision are done with help of the Chile Preparado program. This program has three ways of giving information. In the first place, it displays all the policies and strategic plans that the government has for making Chile prepared for different natural disasters. In the second place, the program wants to motivate people to prepare themselves for natural disasters with help of public information campaigns on what citizens can do themselves to prepare for natural disaster. Thirdly, it displays all the different warnings on possible disasters on the website of the Ministry of Public Safety (ONEMI, 2017).

During an event warning systems are used to notify citizens of possible danger. For example, when an earthquake occurs alongside the coastline, a warning is broadcasted to notify that there is a possible tsunami coming. Evacuation procedures are executed directly when this occurs. Every two years, in the coastal towns, these procedures are simulated to let the citizens of these towns learn what they have to do during a real earthquake event (ONEMI 2016; Interview Díaz). Together with other explanations on how to prepare for disasters citizens will be better able to act according to plan during a disaster. However, mitigation measures that can be implemented before a disaster are not yet well evolved. Local authorities do not have a lot of possibilities to implement measures like planning restrictions and the use of broad mitigation measures, for example the proposed mitigation park in Concepción and the coastal forest in Constitución. Municipalities and regions do not have enough strength to develop this and are not steered in a clear framework by the National Government (Contreras Gatica & Beltrán Benítez, 2015; Herrmann Lunecke 2015; Long, 2015).

As stated by Bakema and Díaz in their interviews, Chile has a centralized form of state in which there is a low amount of room for local actors to move in a different way than the central state proposes. The ability and possibility for local citizens and authorities to improvise is therefore not well evolved. However, there are two examples that make clear that citizens are also

motivated to improvise. The first example are the campaigns that have as a goal to learn people what the hazardous risks in their living area are and get motivated to prepare themselves (ONEMI, 2017). The second example is the provision of subsidies to victims of the 2010 earthquake, so that they are motivated to reconstruct their houses themselves, with help of a certified constructor that has knowledge on how to build in an earthquake resistant way (MINVU, 2011; Useem et al., 2015; ONEMI, 2016). This means that the citizens get more and more space to act and to improvise.

#### **5.1.4 Leadership**

The main efforts in Chile on dealing with earthquakes are made by ONEMI, the national emergency office. In essence they are the leading authority through every level of government (Interview Bakema; Interview Santibañez; ONEMI, 2016). With help of the National Policy for Disaster Risk Management and the project of Chile Preparado they have made sure that there is a clear path and vision for improving the resilience against earthquakes in Chile. It is based on five goals: Strengthening institutions, strengthening monitoring and warning systems, encouragement of culture of prevention and self-insurance, reduction of factors that cause side risks and improving the preparation before disasters (ONEMI, 2016; Platt & So, 2016; Interview Díaz).

Although these goals and the strategic plan in itself reveal that Chile has a visionary approach for where they have to go, there is a mismatch between the local actors, whom are seen as an explicit collaborator for a successful policy, and the plans of the government (ONEMI, 2016). In the strategic plan municipalities and the regional government should be the most important actor in preparing the areas for disasters. However, in practice, local municipalities do not have the resources or have to stick to the strict framework laid down by the central government (Contreras Gatica & Beltrán Benítez, 2015; Herrmann Lunecke 2015).

A positive role can be played by the president of the country (Useem et al., 2015). After the 2010 earthquake president Piñera was appointed just two weeks after the event and set up an emergency plan that would move very fast and would cut through bureaucratic blockades. This disaster had to be overcome to make Chile a resilient country again. His plan and method, as described by Useem et al. (2015), focused not only getting the country back to its normal level, but also to make it stronger with help of insurances, quick rebuilding and a clear division of tasks. These tasks were divided by having lieutenants appointed per region. These lieutenants were kept accountable for every decision and problem.

There were a lot of positives concerning the method of the president. First of all, the reconstruction of housing was done together with private and insurance companies, which made the rebuilding of housing efficient. Secondly, electricity grids and water supply were working again after just one week and hospitals and schools were functioning 100% after one month. However, where the method was lacking was in the collaboration with the local and regional actors. The major part of the decisions was made without the consultation of for example local citizens and business. (Interview Santibañez; Interview Díaz) As stated before, the political system of Chile is very centralistic (Interview Bakema), and during this situation local actors barely could have influence.

### 5.1.5 Resources

One of the reasons why Chile is a resilient country against earthquakes is caused by their financial prosperity. Relatively to other countries prone to earthquake hazards, for example Haiti and Nepal, Chile has the financial power to prepare the country for disasters (OECD, 2013). During the 2010 earthquake this has been shown in practice. While the earthquake of Haiti in the same year created much more international attention in the form of financial aid, Chile had to restore their country merely on themselves (Franklin, 2015). The Chilean government saw that this earthquake disaster was an opportunity to make the economy stronger than before by investing in infrastructure and to make economic reforms. With help of insurance fees paid by foreign insurance companies plus a growth in tax revenues they made sure that Chile could rebuild itself. On top of that, because the financing of the insurance companies came from foreign countries, the economy could even grow (Useem et al., 2015; IMF, 2010). As stated by Bruneau et al. (2004) this is an essential aspect of a resilient society. A negative side of the Chilean system is caused again by the centralistic system. The emergency office, ONEMI, does not have a lot of financial resources in every region or municipality, so not everywhere safety can be assured properly (Interview Bakema, 10-04-2017; Sandoval & Voss, 2016).

Knowledge levels of all authorities on how to act in during an earthquake event is high, caused by the fact that a lot of research done is on how earthquakes act and on how buildings react to the vibrations caused by earthquakes (Contreras Gatica & Beltrán Benítez 2015; Gonzalez-Muzzio & Henríquez, 2015; ONEMI, 2016). Therefore, the level of human resources is high, although it differs per region. The knowledge in the regions that have had a recent earthquake event are more evolved than the regions with less earthquake events: *“Si, existe una diferencia, por ejemplo en la zona norte las personas recuerdan los últimos terremotos que fueron más recientes y esta experiencia es traspasada a nuevas generaciones”* (Interview Santibañez). This statement makes clear that knowledge on earthquakes is passed per generation. On the other hand, the level of knowledge and skills on the local level is not that high, especially on planning measures that could mitigate earthquake and tsunami impacts. It is still for example possible to build housing without tsunami impact measures in coastal areas (Bronfman et al., 2015; Hermann Lunecke 2015). The lacking of good planning measures means also that resilience is reduced, because, as stated by Khalili et al. (2015) preparation with mitigation measures is one of the four phases to improve the resilience of a region.

### 5.1.6 Fair Governance

The president of Chile has been given a public mandate during elections. Although there have been some examples of corruption of a president (Garate-Neidhardt, 2015) the election has since the downfall of General Pinochet in 1990 been a democratic process (Interview Bakema). This means that decisions in theory have a legitimate basis. However, as stated before, decisions are made in a non-collaborate manner and therefore people do not agree with a lot of decisions that have been made by the government, the region or municipality (Interview Díaz).

The population in Chile is very dispersed and concentrated mostly in the capital, Santiago (OECD, 2013). This causes that regions get different amounts of financing and this is also the case for the preparation of earthquakes. Mitigation measures, mostly focused on the construction of buildings, are more developed in the capital, than in regions with less financial

power. On top of that, after the 2010 earthquake resources for emergency and reconstruction were first deployed in the capital, although other areas were more severely struck by the earthquake (Elnashai et al., 2010; Interview Díaz; Interview Santibañez). There is also inequality in human resources within authorities on how to act during an earthquake. Regions with a recent experience of earthquake disaster management, for example Constitución region, will be more efficient during an event than other regions (Interview Díaz).

Inequality is also reflected in the accountability and responsiveness of the government in several locations. The government promised to restore housing of everyone in the affected regions after the 2010 earthquake through the plan of president Piñera (MINVU, 2011; Useem et al., 2015). However, in 2016 there were still people with no proper housing and living in emergency shelter, like tents or sheds (Romero & Albornoz, 2016). Another case that also diminishes the level of responsiveness is that national plans are not based on ideas of local municipalities and communities (Interview Santibañez).

With help of national strategic plans, the most recent one in 2016 (ONEMI, 2016), Chile tries to reduce risks of disasters. However, the structure of planning and decision-making does not favour the creation of risk-reduction and increase in resilience (Sandoval & Voss, 2016). In the case of planning, coastal areas do not have sufficient mitigation measures to prevent the major impact of a tsunami (Herrmann Lunecke, 2015). On top of that, there is a lack of coordination between layers of government, which worsens the efficiency of disaster management as well (Sandoval & Voss, 2016; Interview Bakema). Secondly, there are different examples of inefficient use of subsidies for recovery and mitigation projects that not have been finished (Sandoval & Voss, 2016). However, several positive examples, like the coastal forest park in Constitución and the mitigation park in Constitución have proven that several regions can increase safety while also improving liveability (Intveen, 2014; Long, 2015; Interview Díaz; Interview Santibañez).

# BOX 1: Stakeholders

## Chile

Chile has a centralistic system. During a national disaster, the responsibility lays with the *President of the Republic*, who often acts as leader of the country to come back from disaster. Planning beforehand is partly done by MINVU, because they take planning decisions and measures before disasters. They are for example responsible for the building codes. MISP is the other ministry important for this subject, because it is responsible for the public safety. They take preparations for emergency management (MINVU, 2011; ONEMI, 2016). End responsibility though for emergency management and preparation lays at *ONEMI*, which is advised by two knowledge entities: *CSN* and *SHOA* (ONEMI, 2016). They give information on the frequency and power of earthquakes and tsunamis. ONEMI operates on different scales, every level of government has an ONEMI operation next to them on the same level. From figure 9 it becomes clear that the system is very centralistic, every government lower then the ministry is dependent on the one above them. Decisions taken are therefore majorly done by the highest level of government (Interview Bakema).

## the Netherlands

The field of actors of the Netherlands is much more complex than in Chile, caused by the fact that gas production plays a role in the decision-making. There is a clear distinction between two parts: the left side are actors that play a role in gas production and the right side only play a role in damage handling. However, they stay dependent on the actors that cause the earthquakes. The ministry of EZ (economic affairs) is the important actor of the state. Through EBN they own 50% of the *Maatschap Groningen* which takes decisions on gas production and is the first actor to gain profit. The other 50% is owned by NAM, the exploiter of the gas field in Groningen (OrV, 2015). The NAM is owned by two private and multinational companies, Exxonmobil and Shell, which makes them financially powerful. *Gasterra* is a company that also is partly owned by the state: it buys and sells the gas. The final actor that plays a role in the gas production is SodM which gives advise on the level of production that should be used and whether NAM plays by the rules of the government. The right side is only focusing on the safety of the region. CVW is a company, officially independent but financially and legally supported by the NAM, that processes damage claims. They get a lot of critique on their inefficiency and slow acting. Critique is even more fierce because the CVW is not acting independent from the NAM, an important stakeholder in the gas production part. Since 2014 though, province and municipalities are, supported by the state, acting together in the NCG. They have taken the responsibility now for checking houses on earthquake damage and providing compensation after NAM has pulled out of the damage compensation process (De Veer & Van Hofslodt, 2017). From figure 10 though it becomes clear that citizens are in between a lot of influential actors and can not have a lot of influence on the decision-making.

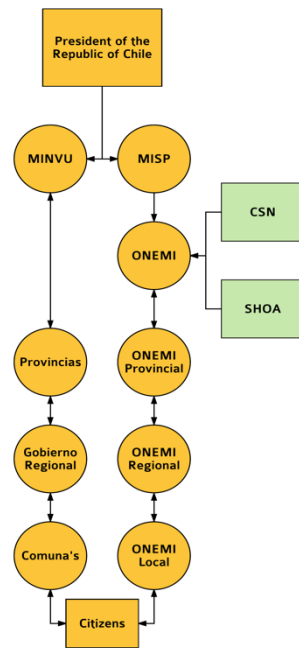


FIGURE 9: OVERVIEW OF STAKEHOLDERS IN CHILE

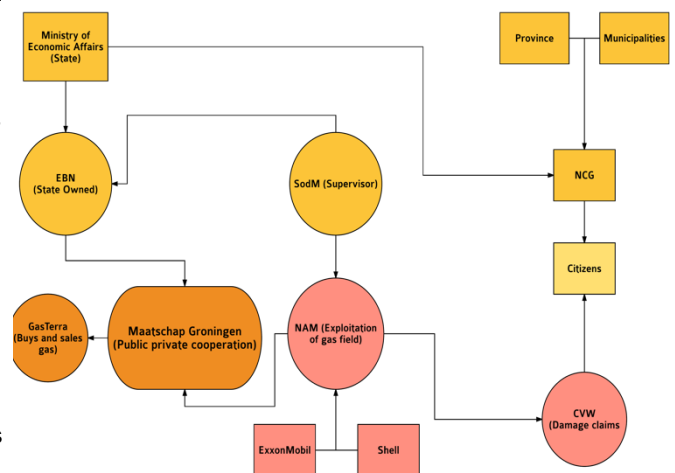


FIGURE 10: OVERVIEW OF STAKEHOLDERS IN THE NETHERLANDS



## 5.2 Adaptive Capacity Wheel of the Netherlands

After the explanation of the adaptive capacity wheel of Chile, this section explains the adaptive capacity wheel of the Netherlands on basis of the interviews and literature review. Box 1 gives an important context because it is an overview of all the actors involved in the decision-making process in the Netherlands as well as in Chile.

### 5.2.1 Variety

As stated before, the Netherlands is an unexperienced country concerning earthquake disasters (Orv, 2015). Therefore, the different approaches for solving safety issues and improving the economy and the liveability of Groningen are fairly new. However, there are several solutions provided.

Because damage to housing is the main issue, the process of damage treatment and processing of claims are most important solution. With help of the actor that has caused the damage, namely the NAM, damage is checked. An expert will make a report and decides whether the damage is caused by earthquakes or not. If this is the case, the NAM needs to restore the damage or to provide a compensation (Interview Rots). Since 2016 The houses are not checked anymore by the NAM itself, but by the NCG. On basis of their damage protocol, which will get an update in 2017, they make decisions on whether a house needs compensation.

Other solutions provided for housing are for example the “value increase scheme”, a measure that helps people to increase the worth of their house with help of for example solar panels and renovation (Interview Fossen). Another measure is the pilot “Heft in Eigen Hand”, in which people can decide themselves how they want to refurbish their housing with funding of the NAM (NCG, 2015; Interview Steenbergen).

However, the safety is not the only issue that needs to be dealt with in the region. Solutions that are provided are therefore from different perspectives: safety, energy, liveability and population shrinkage (NCG, 2015; De Bruijn et al., 2016). Because the earthquakes are correlated with the production of gas, the energy issue is of high importance. Increasing the safety of the region is also seen as an opportunity for the region to become more resilient with help of a sustainable energy supply. Houses that need refurbishment or reconstruction are made sustainable and opportunities for other sustainable energy provision are researched to replace the gas (Interview Fossen; Interview Steenbergen). Improved liveability is created with help of small projects, for example communal gardens, playgrounds or the refurbishment of village housing (Kansrijkgroningen.nl, 2017). To cope with the shrinking population in the region, new housing or construction projects are checked from this perspective. For example, new school buildings were needed in the town of Loppersum for two different organisations. The municipality and the school boards chose to merge together, because they knew that the number of children would decrease in the coming years (Interview Rots).

As becomes clear from Box 1, the amount of actors that play a role in the decision-making and the processing of compensation claims is high. Therefore, decisions taken go through different levels of governance and different actors. Municipalities and the province have the opinion that they do not have a lot of influence on decision-making, which is mostly steered by the national

government and the gas production companies (Interview Kingma; Interview Rots; Interview Gerritsen). On top of that, citizens are powerless against decisions concerning earthquake solutions and the level of gas production. The measures that are taken to refurbish housing are experienced by citizens as slow and inefficient (Interview Fossen). There are several examples of people that have to wait at least 5 years to get a decisive answer on their compensation trial. This makes clear that the process of making Groningen safer is stiff (Interview Kingma). An important cause is the large amount of actors with different stakes that play a role in this situation (Interview Van Gelder). Another issue that makes measures possibly inefficient is the high uncertainty on the induced earthquakes and the consequences of them. More intensive research is necessary to reduce this uncertainty. With more research, the reliability of the NPR, the building standard for construction in the Netherlands, can be increased and therefore constructions more safe (Stuurgroep NPR, 2015; Interview Fossen).

One of the solutions that is named by the citizens, but is not very interesting for the National Government, is stopping the extraction of gas. As explained in chapter four, the extraction of gas causes the subduction of the surface and therefore, the earthquakes take place. Although there is still uncertainty, the frequency and magnitude of earthquakes will decrease when the gas extraction is decreased as well (TNO, 2014). Decreasing or even stopping the gas production is one of the solutions that the national government could consider, when it is combined with investments in a more sustainable energy supply (De Bruijn et al., 2016; Interview De Bruijn).

### **5.2.2 Learning Capacity**

An important problem, stated by many interviewees of this research, that reduces the level of resilience against earthquakes in the region of Groningen, is the high level of mistrust of the citizens in the national government, the NAM and the companies and authorities that are closely related to these two stakeholders, for example the NCG and CVW (Amin, 2015; Interview Kingma; Interview Fossen). The mistrust has several causes. Firstly, the NAM is experienced as a company that mainly focuses on financial gain and does everything to ensure this. For this sake, they bring several cases to court which takes often more financial costs than the compensation that is subject of the trial. This also is one of the reasons why the processing of compensation claims is experienced as slow and inefficient (NCG, 2017; Interview Kingma,). Secondly, for years worries of citizens on gas extraction and the connection with earthquakes have not been taken seriously and information provision has not been and still is sometimes not transparent (OrV, 2015; Interview Kingma).

The low level of trust is partly caused by the inexperience of the authorities and the uncertainties concerning the situation. This inexperience and these uncertainties are caused by the fact that earthquakes are a relatively new phenomenon for the Netherlands (Van Es, 2012; De Bruijn et al., 2016). Therefore, the Netherlands can not fall back on an institutional memory on how to deal with earthquakes. What they can do however, is to fall back on how to deal with natural disasters, because the country has a high experience in dealing with water flooding disasters. However, until now there has not been made a clear use of this memory by for example declaring the situation in Groningen as national disaster, what has been done with the large flooding in 1953 in the south west of the country (Bockma, 2014; Interview Bakema; Interview De Bruijn).

Because of the inexperience and uncertainty, authorities have a lot of doubt on how to act. Especially because the level of knowledge is not yet evolved to a reliable level. Scientists, working for different institutions, acknowledge that they do not have an overall picture yet of all causes and effects of earthquakes and that there is still a lot of uncertainty (Interview Bakema; Interview Van Gelder). Municipalities and the regional government therefore have to deal with these uncertainties as well and they do not always know whether the chosen method is the correct one (Interview Kingma; Interview Rots; Interview Gerritsen).

However, caused by this inexperience, there is also potential for learning by the government, national, regional as well as local. The NCG tries to improve the process of checking housing on damage after every session, by smoothening the process (Interview Steenberg) and damage reports on different houses are made quicker every day. In the case on double loop learning, the information process has been changed to an open one, even when there is no information, municipalities want to inform their inhabitants (interview Kingma). However, emergency management, what to do when a devastating event takes place, needs more attention. Citizens of the region barely get information on how to act during such an event (Interview Fossen; Interview Bakema).

### **5.2.3 Room for Autonomous Change**

Elaborating on the information process, a major part of the available information is non-transparent and inconsistent. The first flaw on information access from the government is that it is not clearly explained how to prepare your house for an earthquake and what to do when damage occurs to your house. The system to make notice of damage to your house caused by earthquakes is slow and unclear (Interview Fossen). In 2017 a new damage protocol is introduced which should improve this process and make it more easy to report damage, with help of for example personal photos instead of experts that check the damage in person (NCG, 2015; Interview Steenberg). Other flaws are different explanations of safe production levels and putting aside advises of advisory institutions, the low amount of geologists that are not bound to one of the important actors and the lack of information provision of the national government and advisory institutions of the government (OrV, 2015; interview Fossen). However, since 2012 this method has improved someway. The NCG is now the leading entity for the process of restoring damage and housing and the NAM is out of this. Therefore, the provision of information to the people has increased and become more transparent (Interview Steenberg, 29 March 2017). Still, citizens think that the government should be more honest about the risks of earthquakes to make them feel safer (Postmes et al., 2017).

The new plan that is made by the NCG, *Meerjarenprogramma Aardbevingsbestendig en Kansrijk Groningen*, makes sure that there is a clear directive alongside which solutions and initiatives can be implemented. In every quarter of year, the NCG publishes their costs and plans for the coming time in a report, which makes information transparent and usable for local actors (NCG, 2015). These program explanations plus the quarterly reports make sure that the national government wants to be more clear about what they do and how they want to do it. Although this is a positive switch in plan making, a lot of things stay vague and unsure. Inhabitants feel that they do not have the possibility to increase their safety by themselves and if there is, it is not clear how they have to do that. For example, plans for emergencies for a possible earthquake are not available (Postmes et al., 2017; Interview Fossen).

Room for improvisation is therefore not that high. Most of the people do not know how to act before, during and after an earthquake event to ensure safety and how to prepare their house. Information with this background, provided by the national government, is non-existent (Interview Fossen; Postmes et al, 2017). Concerning the reconstruction of housing, there is a pilot called 'Heft in eigen hand' in which people get a financing to fix their houses to their own idea (NCG, 2015). This idea is very popular and it is a start into the direction of increased improvisation possibilities.

#### **5.2.4 Leadership**

The lead in the progress of the restoring of the resilience of the region of Groningen is in hands of the NCG. With their plan *Meerjarenprogramma Aardbevingsbestendig en Kansrijk Groningen 2017-2021* they have created a vision for the region of Groningen, which focuses on safety, liveability, economy and the level of population. This vision is supported by the state, the regional government and 12 municipalities that are located in the earthquake area (NCG, 2016; Interview Steenberg). Municipalities have a vision on what they would like to reach in the coming years and mayors are experienced by the people as their natural leaders (Interview Kingma). However, the 'leader' of the country, the prime-minister of the Netherlands, does not show himself as the protector of the people of Groningen. Citizens of the region do not experience that the prime-minister is very involved in the process and has a clear line of vision to go to (Interview Fossen; Interview Kingma).

The municipalities therefore are the leaders on the local level to encourage people and actors to become active, also because they are highly trusted by the local inhabitants. NCG is trying to take this leading role as well. It has however a lot of scepticism around itself, because of the connection with the ministry of economic affairs, one of the important actors that has financial gains from the gas revenues (Interview Kingma; interview Rots; Interview Steenberg).

The part of the leadership in the Netherlands that is lacking the most is the low level of collaboration between involved actors and levels of governments. This has two reasons. Firstly, the gas production is of high importance for the Dutch state, because it is an important part of the budget. In 2013 the state earned 13 billion euros with the production of gas (Weijssink, 2017). The producing company, NAM, plays a vital role in the decision-making process. Their goal as an enterprise is to benefit in a financial way, which is a position directly opposite of the citizens, who would like to lower the production of gas (Interview Fossen). Secondly, the municipalities and the regional government have started a trial because they do not agree with the decision on how much gas is produced per year. The situation is that the municipalities have as a priority to protect their citizen and that the national government still sees the gas production as too important to give up (Interview Kingma).

#### **5.2.5 Resources**

The Netherlands has sufficient financial resources to cope with the problems that are caused by earthquakes. The country is one of the richest in the world, with a net national income per capita of 42,000 dollars. In comparison, Chile has with a net national income per capita of 22,000 dollars a much lower financial power (OECD, 2017). On top of that, the financial gain out of the gas production is usable for investments in the region of Groningen to improve safety and liveability. This suggestion has also been given by Jaime Díaz in his interview "*Creo que*

*deberían utilizar parte de las ganancias obtenidas con el gas para hacer estudios de mitigación o generar condiciones de mayor resiliencia, ninguna actividad económica justifica generar condiciones de peligro para la vida y los bienes de otros.*” He suggests that gas revenues should be used for research and that financial reasons never should decrease safety of citizens. This means that the Dutch state has the financial possibilities for investing in the safety and liveability measures and should use them. However, it is important to note that not all possibilities are yet used for improving the resilience of the region. One billion has been reserved by the state, through the program of the NCG, to improve the safety and liveability of the region. However, this budget has not been used in an efficient way, because the costs of handling damage claims have been high (ANP, 2017).

Sufficient construction companies in the Netherlands are available to improve housing and buildings for earthquake hazards. An example is a prestigious project in the city of Groningen, namely *The Groninger Forum*. This building is made earthquake resistant and money for this has been made available in an efficient way (Van den Berg, 2015b). Therefore, it is clear that the Netherlands has the possibilities to research earthquake prone areas and has the expertise to build in an earthquake resistant way. On top of that, there are sufficient knowledge institutions who do a lot of research on how the surface of the earth works, what the exact mechanisms are of the earthquakes and how authorities and governments should deal with this situation. Examples are the Technical University of Delft, the University of Groningen, but also the NAM, which, although it is not a neutral player in the process, has a lot of knowledge and expertise on how the surface of the earth moves and what needs to be done to work with this situation (De Bruijn et al., 2016; Interview De Bruijn; Interview Van Gelder). However, a lot of knowledge on how buildings react to earthquakes needs to be imported from other countries (Interview Kingma).

Authorities and governments need to deal with a lot of uncertainties, which makes it difficult to cope and to prepare for a possible disaster (Interview De Bruijn). For example, Jinko Rots states in his interview: “*...mijn hemel, wat gaat dit betekenen. Wat betekent dit voor een heel gebied? Betekent dat(...) er gewoon hele dorpen en wijken over de kop gaan. Mensen moeten hun huis uit, er moet tijdelijke huisvesting komen langere of kortere tijd, hele gemeenschappen die uit elkaar gerukt worden, kinderen die op andere scholen moeten. Dus dat is een gigantische operatie.*” Jakob Kingma as well states that the municipality does not have a clear view on how to act in this situation. This makes clear that the authorities are not sure that they have the capabilities and knowledge yet to cope with this uncertain situation.

### **5.2.6 Fair Governance**

The government, national and regional, and municipalities in the Netherlands are all led by democratic chosen representatives, chosen through legitimate elections. The election of mayors is not done with help of a democratic election, but they have a lot of trust among the population of municipalities because they act as the protectors of the local citizens (Interview Kingma; Interview Rots). Therefore, all levels of government are given a public mandate to take decisions. Decisions on the level of gas extraction, which is directly correlated to the level and frequency of power of the induced earthquakes, are taken directly by the Ministry of Economic Affairs. These decisions can be influenced by the parliament, but in practice this barely has happened since the beginning of the gas production (Weijssink, 2017).

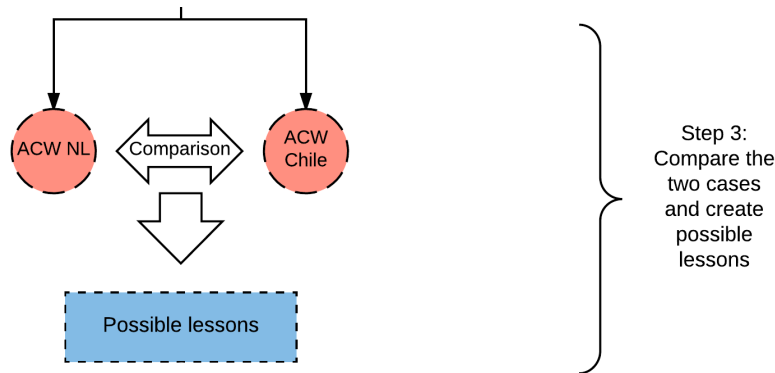
Although decisions on the safety of the region and the level of production of gas have a legitimate basis, these decisions are not beneficial for everyone in the region. The influence of the gas production company NAM, supported by multinational RoyalDutchShell and ExxonMobil, is high and municipalities and local citizens feel powerless against the financial power of these companies and the national state (OrV, 2015; Interview Kingma, 20 March 2017; Interview Fossen). On top of that, local citizens think that there has not been serious research executed yet (KRO-NCRV, 2017). The financial stake of the gas production is more important than the safety stake of the people living in the region. One of the reasons for this is the low amount of people living in the region. Just 0,6% of the people of the Netherlands are victim to earthquake events (Ekker, 2016), while the gas is beneficial for the economy and the energy consumption of the whole country and population (De Bruijn et al., 2016).

These power and financial influences are also the cause of the low response rate of the national government. Although a lot of citizens in the region of Groningen are complaining about the situation and the handling of the damage cases, processes are still slow and decisions are barely in favour of local citizens. There is no full commitment of the national government, proven by the fact that the budget of the NCG, for improving safety and liveability, is nearly empty (OrV, 2017; Luyendijk, 2017). Full commitment will be necessary to solve the several issues of the situation in the region, as stated by Jakob Kingma in his interview. *“Nu zijn wij aan de beurt, de overheid doet het nu voor u als inwoners. Dus als wij het niet goed doen, dat kan niet. Wij doen het dus goed. Punt.”*

Why this is not happening is caused again by uncertainty as well as the fear for an untenable and unpayable situation. The national government does not know yet how large the consequences are that need to be solved to make the region of Groningen resilient for earthquakes (Interview De Bruijn; Interview Fossen; KRO-NCRV, 2017). An example is that several villages potentially could be partly demolished because of the damage caused by the several earthquakes (Interview Rots). Neglecting action can worsen the situation severely and this makes the level of accountability of the Dutch government low.

### 5.3 Comparing the wheels

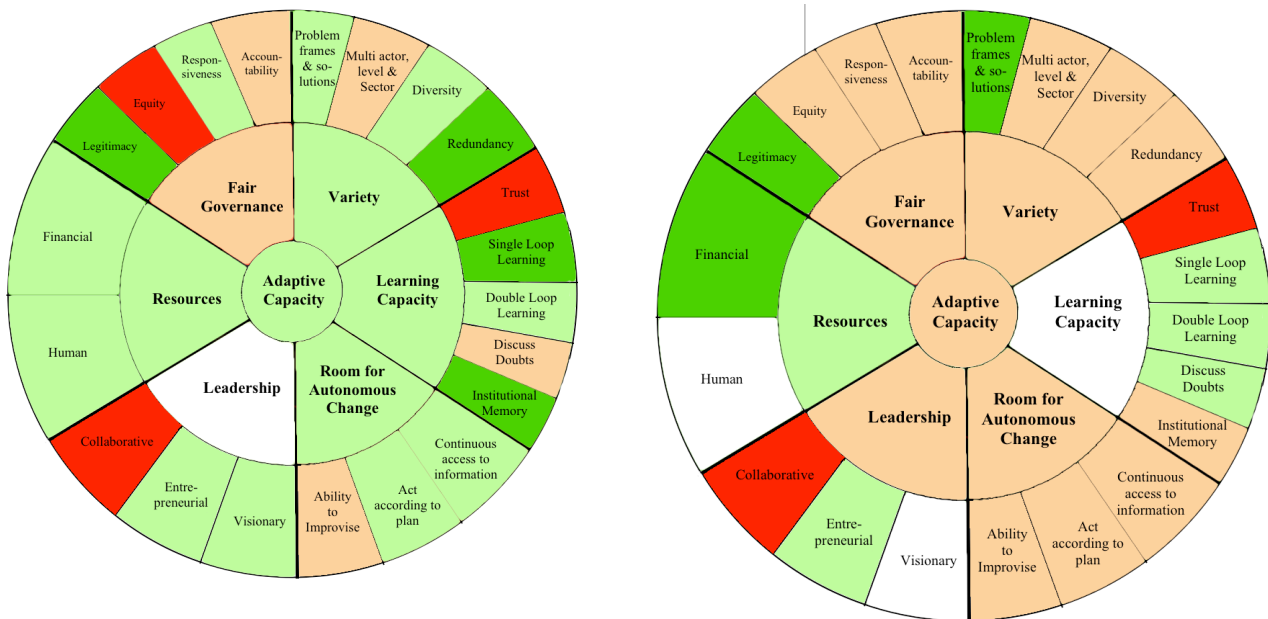
The last two sections have explained the several dimensions of the Adaptive Capacity Wheel to give an overview of the level of resilience against earthquakes in Chile as well as the Netherlands. This means that they form the input for the scores of the two wheels. This section explains and compares the two wheels. In figure 11 the position of this section in the conceptual model is displayed.



**FIGURE 11: THE THIRD STEP OF THE CONCEPTUAL MODEL: COMPARING THE WHEELS TO CREATE POSSIBLE LESSONS.**

In figure 12 the two adaptive capacity wheels are displayed. Comparing the two wheels make clear that there are several differences between the two countries, although there are also several similarities. In this section these differences and similarities and which lessons can be taken from this are explained. Every dimension is compared between the two countries and with examples of methods from Chile possibilities are given on how to improve the resilience in the Netherlands.

First of all, the level of variety in Chile is higher than in the Netherlands. This is caused by the more redundant and variable way of acting in Chile. Technical solutions form the basis of making the country relatively safe for earthquakes. Building codes ensure that buildings are made earthquake resistant and Chileans have a high level of trust in these codes. They feel safe because of them (Interview Bakema). The Netherlands make use of one standard, the NPR, but it is not certain yet whether this standard is strong enough for ensuring safety. More research into the earthquakes motions and on the reactions of buildings should ensure the reliability of the NPR to make people also feel safe, which right now is not the case for everyone (Stuurgroep NPR, 2015; Interview Fossen; Interview Steenbergen).



Effect of institution on Adaptive Capacity	Score	Aggregated scores for dimensions and adaptive capacity as a whole
Positive Effect	2	1,01 to 2,00
Slightly Positive Effect	1	0,01 to 1,00
Neutral or no effect	0	0
Slightly negative effect	-1	-0,01 to -1,00
Negative effect	-2	-1,01 to -2,00

**FIGURE 12: THE ADAPTIVE CAPACITY WHEELS OF THE NETHERLANDS (LEFT) AND CHILE (RIGHT)**

Increasing safety with help of strict standards does not directly mean that the total resilience of the country is increased, because it is necessary to have a broad and diverse strategy to come back from disaster (Bruneau et al., 2004). Chile has this broad strategy with help of a national strategic program to reduce disaster risks, namely the preparation program *Chile Preparado*. This program informs the public on how to act and prepare for several sorts of disasters. Besides the program, the Chilean government provides efficient use of subsidies to repair housing and has installed a private insurance system for earthquake disasters (MINVU, 2011; Useem et al., 2015; ONEMI, 2016). With the program of the NCG the Netherlands has as well a clear strategic plan on where to go to with the region of Groningen, but information on how to prepare for disasters is lacking behind. On top of that, the subsidies scheme of the Chilean government is a lesson for improving the damage handling in the region of Groningen, which is now experienced as slow, inefficient and unfair (Interview Fossen, 5 March 2017).

Levels of trust in both countries is low. In Chile this is caused by the lack of acting by the government, national as well as local, during and after the earthquake of 2010. Authorities are now working hard to get this trust back, by changing their methods and investing in more efficient planning. But still, the trust in government authorities is very low (Bronfman et al., 2016). It makes two things clear. Firstly, to get trust back actions that are directly felt by the public are necessary to improve safety and liveability. Secondly, getting back trust is time-



consuming. It therefore also involves an active attitude of the population, so that their mental resilience is increased as well. This means that the institutional memory also will be increased, which is an important asset for having a high adaptive capacity (Interview De Bruijn; Gupta et al., 2010).

How active the population becomes, also depends on the possibilities they get. The Chilean government has created sufficient room for autonomous change by providing transparent information on all aspects of earthquakes: level and frequency of earthquakes, what the reactions are of buildings and housing, what people can do to prepare for earthquakes, what the people have to do during an event with clear emergency plans and what the government does themselves to prepare the country for earthquake and other disasters (ONEMI, 2016; CSN, 2017). This improves the ability to act according to plan as well as to improvise, although the centralized system of Chile blocks major involvement of the public (Interview Bakema; Interview Díaz). Major improvements can be made in the Netherlands with this lesson. The government can improve the availability of information by doing more intensive research and by being transparent of the findings, their plans to improve safety and liveability and the reasons for them. On top of that, they can prepare the inhabitants of the region better for a possible disaster with emergency training, so that they are not totally dependent on the actions of the authorities.

Leadership is one of the lacking parts in the method of the Netherlands. With help of the plan of the NCG a leader has been 'created', that has a clear vision on where to go to with the region of Groningen. However, its leadership is experienced as vague and not yet resolute. This is because they still have to fight against the influences of the most important actors that gain money out of the gas production and because they have a connection with an important actor: the Ministry of Economic Affairs (OrV, 2015; NCG, 2016). Although Chile does not have a perfect leadership model, because of their non-collaborative method, presidents of the country are acting during and after a disaster as a leader and protector of the people (Useem et al., 2015). Essential in this case though is to take action together with the people and local governments to make interventions that fit to the location. The Chilean government did not do this which caused that they are highly criticized by the people about their actions (Bronfman et al., 2015).

Resources, financial as well as human, are available in the Netherlands, but they are not used in an efficient or full-committed way yet (OrV, 2015; Interview Díaz). Gas revenues can be used to invest in the region and to repair houses and make them earthquake resistant. The commitment of the national government is not high enough yet though, which is caused by the fact that the electorate of the region is not that high in the region. Only 0,6% of the population of the Netherlands is victim to earthquakes (Ekker, 2016). Compared to the earthquake in 2010 in Chile, when 75% of the population was touched by the earthquake (MINVU, 2011), this is a minor amount of people. This indirectly also explains why the Chilean government wants to be highly involved in the process. With help of funds from the copper mines, higher taxes and flows of money from insurance companies they ensured that there were financial possibilities for repairing housing and improving the regions struck by the earthquake (MINVU, 2011; Useem et al., 2015). All three financing methods are possibilities that the Netherlands should consider if they want to make the region of Groningen resilient for earthquakes.

Fair governance is not the strongest point of both countries. In Chile there are problems with equity between regions and people. The financial most powerful regions and persons are the

most resilient, but poor people living in for example shanty towns are still weakly protected for earthquakes. On top of that, government promised to ensure housing for everyone in two years (MINVU, 2011). In 2016 though, there were still people living in emergency housing, which partly has decreased the trust in the government (Gonzalez-Muzzio, 2016). A lesson that can be taken from this is that the Netherlands should make a plan that involves actors in a more democratic way and work together with those actors in making the plan successful, listen to the ideas of local inhabitants and governments to improve equity and mutual trust and be honest about what you know and what you do. This honesty is essential and needs to be done according to Kingma: *“En wie kan het beste met burgers omgaan? Volgens mij de gemeenten en niet het rijk. Ik zeg niet dat ze het goed doen, ze doen het heel goed. Maar, wij roepen altijd: wees gewoon open!”* On the other hand, the first steps are taken. The plan of the NCG, *Meerjarenprogramma Aardbevingsbestendig en Kansrijk Groningen*, is a first step in creating more openness and better listening to the citizens (Interview Steenbergen).

## 5.4 Summary

This chapter has discussed the levels of resilience of Chile and the Netherlands with help of the concept of the Adaptive Capacity Wheels. On basis of these wheels a comparison has been made between the two countries to create lessons for the Netherlands. Several methods, that have been in use in Chile are indicated as potentially useful for the Netherlands. It depends on the willingness and openness of the government in the Netherlands and if the methods are tailor-made to the contextual environment of the Netherlands whether they can be implemented successfully and to prevent a policy failure (Dolowitz & Marsh, 2000).

## 6 Conclusion and Discussion

During this research a comparison has been made between Chile and The Netherlands on how they deal with earthquakes. The main research question to be answered has been:

*“What and how can the Netherlands learn from the resilience against earthquake hazards in Chile?”*

The sub-questions of the research that needed answering are:

- How can resilience and adaptive capacity against earthquakes be defined in theory?
- How can the levels of resilience against earthquakes of the two regions be determined?
- What is the current knowledge level of national and local authorities in general on the case of earthquakes in the Netherlands and Chile?
- What are the different approaches of dealing with earthquakes in the two countries?
- In which policy areas can the Netherlands learn from Chile to improve resilience against earthquakes?
- Which methods of policy transfer or learning can be applied?
- What are the context barriers to transfer policy ideas between Chile and the Netherlands to improve earthquake resilience?

While answering the research questions, three research objectives needed to be reached. The first goal has been to find out whether it is possible to learn from the resilience of others when dealing with earthquakes and whether methods can be transferred to improve the handling of earthquake hazards. Secondly, enriching the concept of policy learning by making use of a new method. The third goal has been to improve resilience against earthquakes in the Netherlands with help of lessons from Chile. This chapter answers the main research question with help of the sub questions explained in the first chapter. Answering the questions will help to reach the research objectives.

The concept of resilience is suitable for describing how well a country can cope with a region, because it describes how a country, region or city can bounce back from a disaster or hazard event (Vale & Campanella, 2005). As described by Davoudi (2012) there are several sorts of resilience, namely engineering, ecological and evolutionary. They are different, but they are all dependent on the levels of vulnerability and adaptive capacity (Engle, 2011). Because of this dependency it is also difficult to distinct the concepts of resilience, adaptive capacity and vulnerability from each other (Adger, 2006; Gallopin, 2006). Therefore, for determining the level of resilience, the Adaptive Capacity Wheel of Gupta et al. (2010) is a suitable tool. Especially because it makes quantifying, which is one of the difficult parts of determining Adaptive Capacity (Yohe & Tol, 2002), easier. Although the method contains still a lot of subjectivity, caused by the fact that during this research the researcher has given his own interpretation of the results to determine the level of every adaptive capacity area. However, the wheel is an easy tool to compare two countries on their level of adaptive capacity and therefore level of resilience.

As stated by Khalili et al. (2015) there are four phases that determine how resilient a region is for earthquakes: planning and mitigation, preparedness, response and relief and recovery. To

achieve this, a high level of knowledge on how earthquakes work, how to prepare for them and how to act during and after an event is essential. The method of Chile has two sides of the coin: on the one hand, because of its long history in earthquakes, they have built up a lot of experience and knowledge about earthquakes, so that inhabitants as well as authorities and governments know what they need to do to prepare for and act after an earthquake disaster. On the other hand, the method is very centralized, without a lot of room for doubts and with a lot of differences between regions. Only negative disasters can change the methods of creating resilience in the country or in certain regions of Chile. However, the knowledge levels in Chile are high: the mechanisms of the earthquakes and the possible consequences of a disaster event are well researched and clear.

The Netherlands on the other hand, have a less informed and more complicated situation, caused by two reasons. The first one is the fact that the Netherlands is unexperienced on how to deal with earthquakes, and therefore on how to prepare and how to deal with earthquakes. From this research it becomes clear that information on earthquakes is not clear yet. For example, several interviewees and sources state contradictable things about the consequences of a certain soil for the propagation of earthquake energy. On top of that, Dutch governments, local as well as regional and national, do not know how to act during this uncertain situation. Secondly, the earthquakes in the Netherlands are induced by gas production and the gas is used for energy and financial purposes, which makes that there are extra actors in play that make decision-making more complex and difficult. On top of that, the trust of inhabitants in the provided information is low because it feels not objective. An important lesson can be taken from Chile here, where information provision on earthquake frequency and characteristics and on how to act during an event is open and clear for everyone. As stated by Folke et al. (2005), this is an essential part of creating resilience, because it gives the opportunity to social actors and inhabitants to act themselves.

Both countries have a different approach for creating resilience against earthquakes, because the causes of the earthquakes in both countries and experience levels of authorities differ. The focus in Chile is on safety for the citizens and coming back from disasters. In the Netherlands the focus is not only on the safety of the citizens, but also on how to get energy supply and financial gain out of the gas production. The national government needs to manoeuvre on the balance between these two stakes. For improving the safety of the citizens of Groningen, that approach should be changed. The level of production needs to be decreased to lessen the magnitude and frequency of earthquakes. Following to that, a transition towards more sustainable energy will be necessary, not only because of the decrease of gas supply, but also because of environmental reasons. To improve decisions about the region in the future, it is essential to learn from events that happened in the past, with help of double loop learning. As stated by Simmie & Martin (2010), a resilient system will become even stronger after a negative event, if it learns from the event and adapts to it.

However, the decrease of gas production is not the only solution necessary for making the region of Groningen resilient for earthquakes. There are several methods that can be learned from Chile in this case. The first one is the investigation and use of a clear standard for earthquake resistant construction. Secondly, improved leadership from the side of the national government. Important is to take decisions in a collaborative way, so that all actors can agree to them. Thirdly, more room for autonomous change with help of transparent information provision and possibilities for inhabitants to act themselves. Fourthly, more provision of resources in the form of subsidies and insurances to increase financial possibilities for making

houses earthquake resistant. Human resources are important as well, more efforts of research should be done on the causes and effects of earthquakes and how surfaces and buildings react to them. Finally, all the last named efforts should be supported by a government that is fair, by being responsive to and accountable for problems that occur. Improving these aspects will help to increase the resilience against earthquakes (Gallopín, 2006; Gupta et al., 2010).

However, implementing the measures successfully in the Netherlands depends on whether they can be transferred and applied (Williams & Dzhekova, 2014). The applicability of these measures in the Netherlands is difficult, because there are a few policy barriers. In the first place, there are relatively few people living in the area prone to earthquakes, namely 0,6% of the total population. On top of that, the gas is still of high importance for the rest of the country. Therefore, it is much more interesting for the government to produce gas, than to decrease the production and increase the safety of the people in Groningen. This causes that the political priority is low. Secondly, the influence of the stakeholder NAM is high, because they do not want to lose their financial gain from the gas field. On the other hand, based on the framework of Williams & Dzhekova (2014), the need for newly introduced method is present. Earthquakes play an important and negative role in the daily life of the people of Groningen. On top of that, the goal of the method of Chile is the same as the desired situation of the inhabitants of Groningen: a place to life that is as safe as possible.

So, what and how the Netherlands can learn from Chile is the following. A voluntary policy transfer could be possible. As stated by Dolowitz & Marsh (2000) a voluntary transfer can take place when something is not functioning well in a country and actors want to change this. However, as stated before, the political priority is not present to make it possible. The lessons taken from Chile should be seen as a possibility of lesson-drawing, also because the tacit knowledge on how to act before, during and after an earthquake is difficult to transfer (Stead, 2012). The method of Chile should be an inspiration for the Dutch government to take steps towards a more earthquake-resilient Groningen. To increase the level of urgency, a possibility is to see the situation in Groningen as a natural disaster that needs solutions. This worked as well for the flooding disaster in the south-western part of the country in the fifties, where safety has been increased significantly with large investments in the sparsely populated region (Deltawerken.com, 2017).

The inspiration for a better method is necessary though, because the Netherlands are inexperienced on how to handle the consequences of earthquakes. The ideas from Chile can be used to take a first step towards a resilient policy method focused on improving the safety and liveability of the region of Groningen. On top of that, it can be inspiration for the national government that one of the main goals of governance is to ensure the safety of the citizens. This so that the Netherlands and especially the region of Groningen become resilient for earthquakes.

## 7 Reflection

The previous chapter has presented the conclusions of this research and given the answers on the research questions. This chapter, the last one of this paper, reflects on the research process. This consists of three parts. In the first place, it explains which parts of the research could be improved and in which way this should be done. Secondly, it explains what the research has added to planning practice and planning theory. Finally, the paper is finished with the recommendations for future research.

### 7.1 Evaluation of research process

First of all, the theories that have been used during this research have shown to be useful. Especially the concept of the Adaptive Capacity Wheel (Gupta et al., 2010) has shown to be a useful tool for comparing two countries on their method for, in this case, earthquakes. This is caused by the communicative style of the concept. The colours directly make clear in which policy or institutional areas the countries differ and which areas are possibilities to learn. The downside of the concept is that it still involves a lot of subjectivity. The communicative level of the wheel is high, but the researcher still needs to explain its choices of colours to let the audience grasp why a certain colour has been chosen. Another lacking part of the wheel during this research is that it does not contain the aggregate scores within every dimension (see figure 12) Because of the benefit for clarity of the figure, these scores have not been included. However, including the scores could make the colours and numbers easier to grasp for the reader, so that less explanation is needed.

Secondly, the transferability and applicability framework of Williams & Dzhekova (2014) should have been used more intensively to check the suitability of the policies from Chile in the context of the Netherlands. It has been chosen to minimize this partly because of time issues, but mainly because it would have made the research less to the point. The concept of the adaptive capacity wheel has been regarded as sufficient to compare two countries for creating possible lessons. The framework though would be really useful to determine the level of policy transfer.

Finally, the research is mostly based on the interviews taken from stakeholders and experts in the Netherlands. On top of that, two experts in Chile have been interviewed. However, the knowledge on the methods of Chile would majorly improve if also local, regional and national stakeholders are interviewed. Now, the real intrinsic knowledge on how for example municipalities prepare for earthquakes and what they do to help their citizens is lacking. On top of that, information on how municipalities and regional governments feel about the efforts of the national government is absent. Because of practical reasons this has not been done. The researcher has lived in Chile for half a year. This was enough to find inspiration for the subject and to create a few connections with researchers. But it was not sufficient time to execute interviews with authorities, governments and societal organizations.

### 7.2 Addition to Planning Practice and Theory

For planners the use of comparison and lesson learning is a useful tool, especially for evaluation methods. This research has partly shown this. With help of the adaptive capacity wheel it becomes clear that a country like Chile is more resilient for earthquakes than the

Netherlands. The inspiration that comes from this finding can be used by planners to evaluate their own methods and to find improvements, possibly on basis of the method of Chile. In this way the knowledge gap stated by Stead (2012), that it is not clear how to transfer best practices between countries, is partly filled. In this way, policy transfer can never be completely executed, but inspire planners to change their own methods.

Planning theory on disaster relief and earthquakes has partly been improved by this research by using a different tool for comparing two countries on how they approach the phenomenon of earthquakes: the adaptive capacity wheel. As stated before, the concept has shown to be useful for comparing two countries and to define areas where lessons can be learned. For example, from the research it becomes clear that the institutional memory is much stronger in Chile than in the Netherlands (see figure 4). This partly explains why the Netherlands is less resilient and that this is an area where they will need to make a lot of steps. Therefore, the Adaptive Capacity Wheel is a very useful tool for comparing countries on their level of resilience.

The results of this research have mainly focused on solutions to improve the resilience against earthquakes in the Netherlands. With help of ideas from Chile on disaster relief and response on earthquakes, the approach can possibly be improved. Several solutions have been proposed. First of all, increased research so that a more deeply understanding is created on the mechanisms and effects of the earthquakes. Secondly, improved leadership in a collaborative manner so that all stakeholders are involved. Thirdly, better and transparent information provision for citizens. Fourthly, increased investments with help of national funds or gas revenues. Finally, a change of mind-set by the government, so that they become more responsive.

These ideas are not only proposed with help of this research, but are used in several disaster resilience literature pieces. For example, Shubham (2017) describes several parts that make a city resilient. He states three things which are complementary to this research.

- It is essential to work together with stakeholders in making a city resilient.
- Vulnerability studies are important to take well-informed decisions
- A good information provision system needs to be developed to give citizens the ideas what they need to do or what they can do.
- The level of vulnerability to disasters of a region depends for a major part on financial power or poverty levels.

Alongside several other aspects, these three points are essential for the level of resilience of a city or region. Another entity that works with these ideas is the UNISDR (2017), which has as a goal to reduce disaster risks in different towns and cities all over the world. They try to inspire cities to take measures to improve resilience with help of for example disaster scenarios, the strengthening of financial capacity and social capacity and the pursuing of a resilient urban design. These propositions are brought together in the Sendai Framework for Reducing Disaster Risk Reduction, which local authorities can use to make their city resilient. (UNISDR, 2017). It makes clear that resilience for disaster risk is an often used concept in city planning. Policy Transfer, which has been used in this research with help of the Adaptive Capacity Wheel, can help in this to improve learning between regions and cities.

However, this research makes clear that financial stakes and electoral power are an important influence on decision-making for disaster reduction. For example, the political

priority for doing research and crafting solutions in Groningen. The national government regards energy safety and the financial gain more important than the safety of 0,6% of the people living in the Netherlands. Therefore, resilience theory on planning for disasters would become more successful if it incorporates political decisions and influence in a more convincing way.

### **7.3 Recommendations for Future Research**

This study has had three goals: find out whether it is possible to learn from another region in dealing with earthquakes, improve the method of policy transfer and find a method to increase the resilience of the Netherlands against earthquakes. Although the research has successfully reached these goals, there are two aspects that need deeper research.

First of all, it is essential to do more research in the Netherlands focusing on the causes and consequences of the induced earthquakes. This is necessary to have a deep understanding on the earthquake mechanisms and to take measures that are useful. More knowledge will decrease the level of uncertainty for authorities and citizens.

Secondly, to improve the policy learning in general and for the Netherlands, the methods of other countries in earthquake areas should be researched. Examples are Japan and Italy, where a lot of earthquakes occur (USGS, 2017). On top of that, regions that have to deal with induced earthquakes should be researched. An example is The United States, where authorities need to deal with induced earthquakes caused by fracking (Mccomas et al., 2016). It is interesting to have a look into this case, for example to reveal how they deal with the debt claim, how powerful non-governmental actors are and how citizens react to these earthquakes. If more lessons are created from different regions, then more practices can be easily transferred between regions. This will make sure that more regions can be made resilient for earthquakes.



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# Appendix 1: Explanation of Interview and Coding List

## Interview-guide actors the Netherlands

This guide will give an overview of the questions that will be used during the semi-structured interview sessions with actors and experts that play a role in or have a knowledge about the situation of earthquakes in the region of Groningen. The questions in this guide will follow the concepts of the Adaptive Capacity Wheel and the Applicability and Transferability Framework as guideline. This is necessary for answering the questions of applicability and transferability and to assess the criteria of the Adaptive Capacity Wheel. The questions are grouped per criteria. Note: not all questions apply to all actors. A clear difference is made between questions for experts and questions for actors. However, all have the goal to assess the situation of the province of Groningen while dealing with earthquakes.

### Introducing Questions

- Welke rol speelt/kan u spelen binnen de huidige en de toekomstige situatie van de regio Groningen?
- Wat is uw connectie met de aardbevingen in Groningen?
- Hoe zou u de situatie waarin de regio Groningen zich bevindt karakteriseren?
- Welke binding heeft u met de regio Groningen?

### Leadership

- Wie heeft of hebben, in essentie, de leiding over alle acties die uitgevoerd worden in de regio Groningen met betrekking tot aardbevingen?
- Hoeveel inbreng heeft u als organisatie/gemeente?
- Welk idee zit achter het gevoerde beleid? Wat heeft u als doel voor de regio voor zich? (Focus alleen op aardbevingen of ook op extra ontwikkelingen?)
- Hoe voelt het vertrouwen onder de bevolking, is dit voldoende of goed? Zo ja, waarom denkt u dat? Zo nee, hoe wilt u dit gaan verbeteren?
- Welke inbreng hebben andere actoren, is er sprake van samenwerking?

### Autonomous Change

- Hoe wordt ervoor gezorgd dat de verschillende actoren worden geïnformeerd?
- Welke kansen worden er aan mensen geboden om zelf hun situatie te verbeteren? Worden er bijvoorbeeld subsidies verstrekt als ze zelf de handschoen willen oppakken? En zo ja, voor welke doeleinden en onder welke voorwaarden?

### **Learning Capacity**

- Wat hebben jullie als organisatie/gemeente geleerd van de gebeurtenissen de afgelopen jaren?
- Hoe is daarop gereageerd, of wat hebben jullie met deze lessen gedaan?
- Heeft u ooit adviezen aangenomen van andere instanties/overheden? Ook over de grens?

### **Resources**

- Uit welke financiële bronnen kunt u putten? Precieze cijfers zijn niet nodig, maar denkt u dat het voldoende is voor het verbeteren van de Groningse veiligheid en het door ontwikkelen van de gemeente/regio?
- Is er voldoende expertkennis aanwezig binnen uw gemeente/organisatie voor het behandelen van de verschillende zaken?
- Waar worden de bronnen aan besteed?

### **Fair Governance**

- Wat vindt u van de behandeling van de zaken door de overheid?
- Wie staat er achter uw beleid/visie? Wat wordt er aan gedaan om meer mensen hier achter te krijgen?

### **Variety**

- Met welke scenario's houdt uw gemeente rekening? Op welke manier wordt er rekening gehouden met deze scenario's?
- Wat wordt er gedaan met andere visies van bijvoorbeeld lokale ondernemers die kansen zien in de regio? (Sturend: wordt elke belanghebbende betrokken bij besluiten over de behandeling van aardbevingen?)

### **General Questions**

- Is er volgens u voldoende onderzoek naar de oorzaken van de aardbevingen in de regio Groningen?
- Heeft Nederland voldoende kennis om oplossingen voor de oorzaak en de problemen te zorgen? Hoe wordt er bijvoorbeeld omgegaan met de belangen van andere stakeholders?
- Is het zoeken van oplossingen door Nederland efficiënt?
- Tegen welke barrières loopt men op als er maatregelen worden ingepast? Is het huidige beleid van de Nederlandse overheid tegenwerkend?
- Denkt u dat er politieke acceptatie gecreëerd kan worden voor een beter gepast beleid van buitenaf, bijvoorbeeld vanuit een ander land?
- Wat is uw verbinding met de overheid/met de gasbaten/met de bewoners van de provincie Groningen?
- Hoe kan de NAM uitgesloten worden van de behandeling van de schade, maar toch garant staan voor de uitbetaling van schade?

- Op welke gebieden ziet u risico's voor de veiligheid in de regio Groningen?

### End Question

- How does the future of the region of Groningen look like, what is your vision?
- → What will be necessary to reach this vision?

### Coding List

The list of coding is based on the concept of the Adaptive Capacity Wheel (Gupta et al., 2010) and partly on the Transferability and Applicability Framework (Williams & Dzhekova, 2014). This makes it easy to fill in the adaptive capacity wheel and to check the ability to transfer or learn from policies on basis of the interviews. The transcriptions and recordings of these interviews can be requested at the researcher. This list has also been used for the interviews with the experts from Chile. The translation of this interview is displayed in appendix 3.

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#### *Codes based on adaptive capacity wheel*

<b>Variety</b>	Problem frames & solutions
	Multi-actor, -level & -sector
	Diversity
	Redundancy
<b>Learning Capacity</b>	Trust
	Single Loop Learning
	Double Loop Learning (Important moments in time)
	Discuss Doubts
	Institutional Memory
<b>Room for Autonomous Change</b>	Continuous access to information
	Act according to plan
	Ability to improvise
<b>Leadership</b>	Visionary
	Entrepreneurial

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	Collaborative
<b>Resources</b>	Human
	Financial
<b>Fair Governance</b>	Legitimacy
	Equity
	Responsiveness
	Accountability

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***Codes for transferability and applicability***

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Risk status

Need

Prevalence of issue: why important?

Political Priority

(Impact on) stakeholders

Other barriers

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**TABLE 5: OVERVIEW OF ALL CODES**

## Appendix 2: Interview Respondent Scheme

Who?	From Which Organisation?	What role?	Why Important?	What do I want to know?	When?	Where?
Nicolette Steenberg	Nationaal Coördinator Groningen (NCG)	Spokesperson	The NCG plays a vital role in the region concerning earthquakes and has a lot of knowledge on all the different aspects on the dealing with earthquakes in the region of Groningen.	The method of the NCG to make the region resilient against earthquakes and which chances they see to make the region even stronger.	29 <sup>th</sup> of March 2017	Office building NCG
Coert Fossen	Groninger Bodembeweging (GBB)	Board Member	The GBB is an organisation that makes a strong case of defending the rights of the local inhabitants of the region.	The perspective of local inhabitants on the situation. What goes wrong? What goes well? How can it be improved?	17 <sup>th</sup> of March, 2017	Office Building Royalhaskoning DHV (Working location of Coert Fossen)
Jakob Kingma	Municipality of Ten Boer	Coordinator Earthquake Improvement plans	The municipality of Ten Boer is in the middle of the affected area and has to solve problems caused by the earthquakes.	How does a local municipality deal with the problems and on which actors are they dependent?	10 <sup>th</sup> March 2017	Municipality Building Ten Boer
Jinko Rots	Municipality of Ten Boer	Coordinator Onafhankelijke Raadsman in Loppersum	The municipality of Loppersum is in the middle of the affected area and has to solve problems caused by the earthquakes.	How does a local municipality deal with the problems and on which actors are they dependent?	28 <sup>th</sup> of March 2017	Municipality Building Loppersum

Prof. Hans de Bruijn	TU Delft	Researcher on Multi-Actor Governance	Professor De Bruijn is a researcher in public administration and has knowledge on how to deal with problems which incorporates different actors and opinions.	How can the method of the national government and other important stakeholders be assessed and improved?	3 <sup>rd</sup> of April, 2017 15:15	Telephone conversation
Prof. Pieter van Gelder	TU Delft	Researcher on Safety Science	Professor Van Gelder is a researcher on Safety Science and has a lot of interest in the situation of the province of Groningen.	What is the knowledge level right now on the case of earthquakes in the Netherlands and Groningen and what is done or can be done with this knowledge?	21 <sup>st</sup> of March, 2017	Telephone conversation
Melanie Bakema	Rijksuniversiteit Groningen (RUG)	PhD Researcher on earthquakes in New-Zealand and Chile	Melanie Bakema is PhD researcher and has done research on earthquake planning in New-Zealand and has done different research in Chile. Therefore she has knowledge on the method of dealing with earthquakes in different contexts.	How is dealt with earthquakes in Chile, which problems and innovative solutions do they have? What can the Netherlands learn?	10 <sup>th</sup> of March 2017	Faculty of Spatial Science, RUG.
Leonel Santibañez	Universidad de Chile	Researcher at the faculty of Architecture and Urbanism at Universidad de Concepción	Has experience in researching the vulnerability levels of people in regions in Chile that are prone to earthquakes.	What does the Chilean government to reduce the vulnerability and increase the resilience of Chile against earthquakes?	5 <sup>th</sup> of April 2017	Questionnaire per e-mail.

Jaime Diaz Bonilla	Universidad de Chile	Researcher at the faculty of Architecture and Urbanism and represents the university at the National Platform for reducing the risks of natural disasters	As being part of the national platform for the reduction of risks of natural disasters, Jaime Diaz Bonilla has a lot of knowledge on how the Chilean authorities reduce risks of earthquakes in Chile.	What does the Chilean government to reduce the vulnerability and increase the resilience of Chile against earthquakes?	5 <sup>th</sup> of April 2017	Questionnaire per e-mail.

All transcripts and records of these interviews can be requested by contacting the researcher.



### Appendix 3: Framework of Documents

Country	Document	Why Important?	Used For What?	Pages
<b>the Netherlands</b>	Study and Data Acquisition Plan Induced Seismicity in Groningen (NAM, 2016)	Document of the NAM, company responsible for the gas extraction, on how much gas is extracted and how is dealt with	Causes Earthquakes and plan for safety and resilience in the region	147
	KNMI Report Induced Earthquakes (Dost & Spezler, 2016)	Document that gives an overview of the earthquakes that have happened and gives scenarios on different earthquakes that can happen.	The explanation of the mechanism of induced earthquakes.	14
	Meerjarenprogramma Kansrijk en Aardbevingsbestendig Groningen 2017-2021 (NCG, 2016).	Program of the NCG that gives the focal points that should be focused on while making	Used for finding out what the different methods are in the Netherlands and the region of Groningen to improve the	158

		Groningen more safe and resilient in social and economical ways.	resilience against earthquakes.	
	Veiligheidsbeleving, gezondheid en toekomstperspectief van Groningers Wetenschappelijk Rapport #2 (Postmes et al., 2017)	Research on the perspective of the people of Groningen. What do they need and what can the get?	Finding out what the opinion is of the people, whether they are able to take act and to improvise and what they think is necessary to feel more safe.	80
	Impact Assessment Nederlandse Praktijk Richtlijn Aardbevingsbestendig bouwen (Stuurgroep NPR, 2015)	Example of a possible method of building codes that will be used to make the houses earthquake proof.	To explain what the current standard is for earthquake resistant construction is and to find out whether it can be improved.	37
	Aardbevingsrisico's in Groningen. Onderzoek naar de rol van veiligheid van burgers in de besluitvorming over de gaswinning (1959-2014) (OrV, 2015)	Document that has researched the safety risks of the last years of the region of Groningen and	To explain how safe the citizens of the region of Groningen have been the last years and to research what is lacking in the Dutch policy.	140

		how it should be improved.		
<b>Chile</b>	Plan Estrategico Nacional para la Gestion del Riesgo de Desastres 2015-2018 (ONEMI, 2016).	National Strategic Plan of Chile to reduce the risks of natural disasters for its inhabitants	To find out the different strategies and plans that Chile uses for earthquakes.	177
	Politica nacional para la Gestión del Riesgo de Desastres. (ONEMI, 2016)	National policies on lowering the risks of natural disasters	To find out the different strategies and plans that Chile uses for earthquakes.	66
	Estrategias Territoriales Para La Reducción del Riesgo de Desastre. Talcahuano, Chile. (Municipalidad de Talcahuano, 2012).	A local plan of the town of Talcahuano to improve the safety of a town and reduce the risks of natural disasters.	To explain how much influence a local actor has and which plans are made on the local level for creating resilience against earthquakes.	156
	Plan de Recuperación Post Desastre con Enfoque de Gestión de Riesgo y Participación Ciudadana. Comuna de Talcahuano, Region Bío-Bío. (PNUD, 2012)	A local plan of Talcahuano on how to comeback van a natural disaster.	To explain how much influence a local actor has and which plans are made on the local level for creating resilience against earthquakes.	78

	Trust and risk perception of natural hazards: Implications for risk preparedness in Chile (Bronfman et al., 2016)	Explains the trust and the extent to how much the people can do themselves to do their own safety.	To find out whether the authorities in Chile are trusted by the citizens and what the negative parts are of the strategy of Chile.	12
	Leadership dispatches: Chile's extraordinary comeback from disaster. (Useen et al., 2015).	Gives a description of all the handling that the government of Chile did after the major earthquake in 2010.	Is used to describe partly the method of Chile on how to prepare for earthquakes and how to deal with the aftermath of an earthquake.	270
	Resilient responses from communities and companies after the 2010 Maule earthquake in Chile (Gonzalez-Muzzio & Henriquez, 2016)	Explains how public and private entities worked to restore themselves from disaster after the 2010 earthquake in Chile.	Is used for describing whether local citizens in Chile are able to act and to improvise themselves.	11

## Appendix 4: Translation Chilean interviews

**Leonel Santibañez - 05-04-2017**

*1. According to the international media, Chile is a very resilient country against earthquakes, compared to other countries, such as Haiti and Japan.*

*- Do you share this opinion and can you explain why or why not?*

Yes, fundamentally because of the frequency of major earthquakes and the memory that is remaining from generation to generation. For example the great earthquake and tsunami of 1960 in Valdivia spans generations and parents and grandparents transmit the experience of the important of the behaviour of evacuation that must be developed to put in shelter the life.

*- What, in essence, is Chile's method of being prepared for earthquake disasters?*

The transfer of experiences within families, for the last earthquakes people expressed that prevention knowledge was acquired in the family.

*- With this method, how are responsibilities divided between different authorities?*

After the 2010 earthquake, Chilean authorities implemented evacuation plans in all coastal cities, these plans are complementary to the behaviour of the population when evacuating to safe areas, although these plans are still very basic. But, without a doubt, they help to an improved response by the authorities.

*- What are the interventions that the authorities make to improve public safety in the event of an earthquake?*

Implementation of evacuation protocols for the population and constant drills, statistics say that people participating in drills have 50% of surviving in the face of a disaster of this nature.

*- How does the government encourage residents to prepare for earthquakes?*

With the work of the municipalities together with the communities, mainly disseminating the evacuation plans and the practices of "simulations" to prevent deaths caused by an earthquake, this is in charge of ONEMI in Chile.

*2. In the region of Groningen in the Netherlands, earthquakes are not natural but induced. The Groningen region has a lot of gas in the earth and the extraction of gas from the earth is the cause of the earthquakes. The houses and the inhabitants of the region are not prepared. Trust in the government is very low, because it makes money with gas. Trust is an important aspect of improving resilience.*

*- How is the situation with the trust between the government (national, regional and local) and the inhabitants of Chile, when the government should create and implement solutions for earthquake risks? And because the trust is low or high?*

After the earthquake and tsunami of 2010 we could say that in Chile there is a before and after in relation to the prevention programs promoted by the government, this was mainly due to human losses and the great destruction of the public infrastructure of the cities affected that meant large investments of money to replenish them, it is estimated that losses are more than 30 billion dollars, and even seven years after the catastrophe, several cities do not recover 100%. This is the case of the city of Concepción, one of the three most important in Chile.

*- Is there a method by the authorities to improve this trust? What is this method?*

In my opinion disaster education is the main weapon for the defense of communities, earthquakes and tsunamis will continue to exist and perish more frequently. People should be prepared to react in the best possible way at any time and they should be taught from the infantile stage in the schools.

*3. The problem with earthquakes is that they are more or less unpredictable. So it is difficult to prepare it and create resilience in a country.*

*- Do you think that resilience against earthquakes is enough in Chile now and why?*

It is not enough, resilience must be implemented in the curricula of colleges and universities, early education is the main tool for prevention, this still does not happen in Chile.

*- Are there differences between regions in this case?*

Yes, there is a difference, for example in the north area people remember the last earthquakes that were more recent and this experience is transferred to new generations, the same happens in the south where the communities remember the great earthquake tsunami of 1960 (9.5 Of magnitude the largest recorded in the world seismic history), nevertheless in the central zone a great earthquake has not affected in the last 100 years, this causes the oblivion in the people.

*3. To improve resilience is very important to learn from current experiences and history. In Chile there are many experiences in history, for example the Valdivia earthquake in 1960 and the 27F earthquake in 2010.*

*- How is the government learning in Chile about experiences dealing with earthquake risks?*

In Chile there is ONEMI government agency to prevent disasters, after the earthquake of 27F, evacuation plans have been implemented in different coastal cities and drills are frequently carried out at municipal level.

*- These lessons in history, how are they applied into policies? It is possible to use an example.*

We can say that in each locality there is an evacuation plan with their respective routes and safe places, these routes and places have historical and patrimonial characteristics since they have been used by generations, the plans collect this experience.

*4. Another problem in the Netherlands is the factor that the government does not want to be a leader to seek solutions and improve the safety of the inhabitants of Groningen. The reason for that is that the gas gain was more important many years ago than the safety of the inhabitants.*

*- Do you think the Chilean government has a clear leader in seeking solutions for earthquake risks?*

At this moment ONEMI is leading the preventive plans, although it is still in process to improve the creation and implementation of evacuation plans and their dissemination among the communities can see an advance after the great earthquake and tsunami of 27F 2010.

*- How is this leader working, in a collaborative or strict way and alone?*

It functions as an autonomous agency that establishes relationships with communities to facilitate the transfer of information and educate the population, although it exists is not effective enough at present.

*5. In Groningen, the affected inhabitants are very angry. But, there are also inhabitants who want to take initiative to improve the situation. Unfortunately, it is not possible in all cases.*

*- How did the Chilean government deal with citizen initiatives? And in what way does the government motivate people to take initiative?*

The implementation of a network of community leaders is very weak in Chile, which is very different in Japan, for example where leaders have a real participation in decision making in relation to prevention and reconstruction issues. 2011 Tohoku earthquake and tsunami.

*- Do you think that all the information about earthquakes (risks and how they are prepared) are clear to all citizens?*

In the Chilean case, I think that in the last few years it has improved a lot, people say they know evacuation plans and safe spaces, the problem is that this urban infrastructure is still very precarious, that is, only the routes and safe places are listed, but its implementation is basic in relation to health services, potable water and climate protection.

*6. It is clear that the situation in Chile is very different than in the Netherlands. But, the aim of this research is that the Netherlands can learn lessons from Chile. To finish this questionnaire, I have one last question.*

*- What do you think is necessary to create a totally resilient Chile against the risks of earthquakes? Please, also write down which measures are necessary for becoming resilient.*

Incorporate in the curricula, from the infantile stage, the themes related to the Chilean and world seismic history to show the importance of being well prepared for future natural events that can be devastating for human life. Maintain a systematic plan of simulacra that is applied in municipalities, colleges and universities to improve resilience and a more timely reaction.



**Jaime Diaz – 05-04-2017**

Answered by: Jaime Diaz, Research Associate to CITRID - Transdisciplinary Program on Risks and Disasters - Universidad de Chile

*According to the international media, Chile is a very resilient country against earthquakes, compared to other countries, such as Haiti and Japan.*

*Do you share this opinion and can you explain why or why not?*

Indeed, due to the frequency of seismic events, Chile has developed capacities to prepare, respond and recover its effects in a timely and efficient manner. This has not always been the case, for the Maule earthquake (2010) the institutions in charge had a poor performance, which meant a large loss of life due to a timely unannounced tsunami. Since that date, a number of measures have been implemented that have greatly increased the resilience capabilities of the population.

*What, in essence, is Chile's method of being prepared for earthquake disasters?*

Since 2013, the National GRD Platform, made up of public agencies, the private sector, academia and scientific and technical agencies, the armed forces, UN agencies in Chile, civil society and voluntary organizations.

The Platform generated a National Policy for Disaster Risk Management, which guides government programs in these matters and a National Strategic Plan (2015-2018), which defines strategic objectives, programs, actions, deadlines and decision makers that allow to materialize Established in national policy.

The Plan is organized around 5 axes of action:

Axis 1: Institutional Strengthening: Ensure that the Risk Reduction of Disasters is a national, regional and local priority with a solid foundation Institutional framework for its implementation.

Axis 2: Strengthening of Monitoring and Early Warning Systems: To make available timely and quality technical information that allows an efficient and effective risk assessment to be made for decision-making in the activation of relevant courses of action.

Axis 3: Fostering the Culture of Prevention and Self-assurance: To foster a culture of security and resilience in the country, through the use of knowledge, innovation and education.

Axis 4: Reducing the Underlying Factors of Risk: Consider the underlying factors of the country's disaster risk in terms of decision-making in both the public and private spheres, for sustainable development.

Axis 5: Strengthening Disaster Preparedness to Achieve

Effective response: Maintain permanent inter-agency coordination mechanisms to strengthen disaster preparedness. In order to achieve an adequate Risk Management, which ensures a timely, effective and efficient response.

*With this method, in what way are responsibilities divided between different authorities?*

The National Seismological Centre (CSN), a technical unit of the University of Chile, created in 1908, monitors seismic threats throughout the country, with equipment that provides information in real time. The National Emergency Office (ONEMI), under the Ministry of the Interior, is responsible for planning, coordinating and executing activities aimed at prevention, mitigation, alert, response and rehabilitation in the event of emergencies and disasters. The recovery and reconstruction stage is in the hands of various ministries, for which a presidential delegate is usually appointed to act as coordinator.

*What are the interventions that the authorities make to improve public safety in the event of an earthquake?*

*How does the government encourage residents to prepare for earthquakes?*

The government, through ONEMI, has developed preventive plans for various threats, called "Chile Preparado", which consists of maps of threats and safe areas (on line), recommendations for events, emergency kit indications, drill dates And other preventive programs. Through the Ministry of Education and the Ministry of Labor, there are specific prevention programs for students and workers.

*In the Groningen region of the Netherlands, earthquakes are not natural but induced. The Groningen region has a lot of gas and the extraction of gas from the earth is the cause of earthquakes. The houses and the inhabitants of the region are not prepared. Trust in the government is very low, because it makes money with gas. Trust is an important aspect of improving resilience.*

*How is the situation with the trust between the government (national, regional and local) and the inhabitants of Chile, when the government must create and implement solutions for earthquake risks? And because the trust is low or high?*

In 2010 all confidence between governments and citizens was lost. When the earthquake occurred (27 February) the government of Bachelet reacted very badly receiving many criticisms by the little prepared that the country was. Two weeks later, he assumes a new government (Piñera) that carries out an ambitious reconstruction plan to recover the damage in just 4 years. The plan was very successful in terms and number of houses built, but executed in a very authoritarian way without considering the opinion of citizens and putting the interests of large real estate companies and builders. In 2014 Bachelet became president again and in the earthquakes that have occurred - Iquique 2014 and Coquimbo 2015 - the government reacted better and faster than in 2010.

*Is there a method by the authorities to improve this trust? What is this method?*

Now we are working with greater citizen participation, trying not to eradicate the population from their places of origin (unless absolutely necessary) and creating a program of Self-Construction Assisted by professionals.

*The problem with earthquakes is that they are more or less unpredictable. So it is difficult to prepare it and create resilience in a country.*

*Do you think that resilience against earthquakes is enough in Chile now and why? Are there differences between regions in this case?*

Geological studies can predict where an earthquake will occur but not when. Because of its location on the confluence of the Nazca and South American plates, much of the Chilean territory is exposed to seismic threats, so the entire population must be prepared to withstand great earthquakes. Currently working on preventive actions and evacuation drills in several coastal cities, to reduce the loss of lives by tsunamis; Earthquake losses have significantly declined thanks to strict building codes.

*To improve resilience is very important to learn from current experiences and history. In Chile there are many experiences in history, for example the Valdivia earthquake in 1960 and the 27F earthquake in 2010.*

*How did the government learn in Chile about experiences dealing with earthquake risks?*

*This lessons history, how does it apply in policies? It is possible to use an example.*

I think it was already answered.

*Another problem in Holland is the fact that the government does not want to be a leader to seek solutions and improve the safety of the inhabitants of Groningen. The reason for that is that the gas gain was more important many years ago than the safety of the inhabitants.*

*Do you think the Chilean government has a clear leader in finding solutions for earthquake risks?*

*How is this leader working, in a collaborative or strict way and alone?*

The difference is that earthquakes in Chile originate in a natural condition, we can not modify plate tectonics, and in Holland, so you say, originate in an anthropological action of gas extraction. I believe that they should use part of the profits obtained with the gas to do mitigation studies or generate conditions of greater resilience, no economic activity justifies generating conditions of danger for the lives and property of others.

*In Groningen, the affected inhabitants are very angry. But, there are also inhabitants who want to take initiative to improve the situation. Unfortunately, it is not possible in all cases.*

*How did the Chilean government deal with citizen initiatives? And in what way does the government motivate people to take initiative?*

Chile has a very centralized administrative political organization and many times government agencies make decisions without considering the opinions of those affected, provoking the rejection of the solutions proposed, for example by displacing the inhabitants of their places of residence, separating them from their family networks or support circles. Communities should be listened to and considered, since they generally know their territory and their needs better than the authorities. In recent catastrophic events - forest fires, February 2017 - rural or urban communities organized themselves to act on their own, protecting their homes, without waiting for the authorities to act. Obviously the ideal would be to achieve concerted action among citizens, civil organizations and authorities.

*Do you think that all the information about earthquakes (risks and how it is prepared) is clear to all citizens?*

The government and academia provide enough information about earthquake risks and their effects. Each Chilean suffers during his life the effects of at least 3 or 4 large earthquakes (7.0 Mw or higher) and hundreds of small and medium earthquakes, not being prepared is a personal responsibility.

*It is clear that the situation in Chile is very different than in the Netherlands. But the aim of this research is that the Netherlands can learn lessons from Chile. To finish this questionnaire, I have one last question.*

*What do you think is necessary to create a totally resilient Chile against the risks of earthquakes? Please, I also wrote that it is now necessary to be resilient.*

Resilience is not built from day to day, it is a set of related actions to develop capacities in the population and to achieve a sustainable development of the territory. More than 80% of the population lives in cities and that is where the greatest efforts are concentrated to achieve it. In Chile, the loss of lives has been reduced, now we are working to reduce the material losses that are a barrier for development.