High and Dry in the Swiss Mountains?

Evaluative Study into Flood Resilience in Flood Risk Management Policy in Mountainous River Catchments in the Bernese Oberland, Switzerland

Abstract: Flood risks form a threat to society and this threat is growing, because climate change will cause more frequent flooding and economic developments cause the potential damage of floods to rise. Communities in flood prone regions need to be able to withstand and adapt to stress whilst not being harmed in their functionality; they need to be flood resilient. Mountainous river catchments in Switzerland also need to be flood resilient as climate change will make the rivers unmanageable. Flood risk management (FRM) policy is supposed to help the communities become more flood resilient, but does the local Flood Risk Governance Arrangement (FRGA) focus on all aspects of flood resilience, namely *robustness*, *adaptability* and *transformability*? This research evaluates the current state of the FRGA in three mountain river catchments in Switzerland to analyse where the current FRGA is supporting or constraining flood resilience. The analysis of the question `*What dimensions of flood resilience are supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?*` shows that the main focus is on robustness, which is adequately supported, whereas adaptability and transformability require policy changes. Unfit organisational structures and lacking involvement of stakeholders constrain local flood resilience.

Keywords: Flood Risk Management, Flood Resilience, Mountainous Rivers, Policy Evaluation & Transformability

Master's Thesis
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Master's thesis

Radboud University Nijmegen
Nijmegen school of Management
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Wat de rivier genomen heeft krijgen we nooit meer terug,

maar wat we haar nog geven is aan ons.

Preface

Dear reader,

Thank you for reading my Master's thesis, which is the final product of my Master's 'Local Environmental Change and Sustainable Cities' at the Radboud University Nijmegen. After five years of studying, it is with great pride and relief that I am able to present the following document. I have always wanted to write a book. This is not how I had imagined it, but now that it is there, I am not less proud. It is not solely my effort that has brought forth this piece of academic writing. If it were only up to me to write a Master's thesis, it would be much less academic and definitely much less elaborate. My many words of thanks therefore go out to a number of people, because of whom I am now able to present this to you.

First and foremost I want to thank my parents, for their support in the times in which this moment was beyond imaginable.

Secondly, I want to thank my colleagues and friends in Switzerland. Special thanks to dr. Karin Ingold for agreeing to welcome me under her supervision and for welcoming me to the IPW and the university of Bern. Special thanks to Laura Herzog, for welcoming me to Bern and for helping me in my least disciplined times. My thanks also go out to the rest of 'my Bern': Maximilian, Fadri, Ruth, Clau, Sean, Efraim, Livia, Simone, Tofunmi, Jonathan, Mirjam and too many others, to whom I owe the experience of a lifetime.

Thirdly, I want to thank my support in Holland. To all my friends that have let me find my way, I will never forget. You know who you are. I was lucky to have 'lotgenoten', thanks for that Mikko and Merith. To those who still suffer, I wish all the strength in the world. Thanks for the help and the financial incentive Theo. Thanks at last for my proof-readers.

Lastly, I want to thank my supervisor dr. Maria Kaufmann for letting me go where I needed to go. Thank you for letting me find out how I can do what I cannot do. It has taught me more about who I am not, than anything has ever taught me. Thanks for the patience and for seeing through. It was not easy, but the future will prove it was worth it.

To you, my reader I apologise for the lengthiness of this document. I would gladly tell you much more in much less words. I applaud all of you who are able to make it through. Perseverance is an underappreciated virtue in society today. A pint of Guinness at O'Leary's Irish Pub will be awarded to all those who are able to make it through this document.

I sincerely hope this Master's thesis can help the local flood risk management practitioners in the Bernese Oberland, to make their beautiful homes as safe as they have fought so hard for them to be. Every insight you have allowed me to have into the beautiful delicacy of your life in the mountains fills me with the pugnacity to fight for your cause.

Häbet nech Sorg, passet uf euch uf, u löht nech nüt la gfaue!

Merci Viumau,

Steven Daniëls

Content

Chapter 1: Introduction

1.1 The Danger of Flooding

Water is essential to life. Without water there would be no life as we know it. Our economy, our natural surroundings and even our bodies cannot be sustained without (fresh) water (Vörösmarty et al., 2013). With this great need for water we are prone to forget that water can also bring grave danger. When there is excessive water, it can flow into our homes and threaten our loved ones. This risk has been known to mankind for a very long time, as stories about floods have frightened societies since before our era (Frazer, 1916). These ancient stories prove that societies have known floods to be a threat to be feared. That fear has focussed attention to solving the problem over the centuries. A permanent solution to prevent flooding remains to be found however.

Flooding is an aspect of natural hazards and it can cause severe damage to a society. Natural hazards cause difficulties for societies in all parts of the world. Natural hazards are those elements in the physical environment around society that are harmful to society and that are caused by forces outside of society (Burton & Kates, 1964). Multiple natural hazards threaten societies, such as floods, droughts, avalanches, storms and heat waves. The disturbance caused by natural hazards can be managed by natural hazard management. The specific management of the natural hazard of flooding is called flood management.

Flood management has been executed for centuries. Despite centuries of efforts to prevent and manage floods, floods still occur (Summermatter, 2012, Vischer, 2003). Globally, floods have accounted for 47% of the damage of all weather related disasters between 1995 and 2015. These floods affected 2.3 billion people (UNISDR, 2015). When we look at Europe, floods have accounted for 40% of all economic losses caused by natural hazards between 1989 and 2008 (UNISDR, 2009). Floods can therefore (still) be seen as a serious threat to society.

The risk of flooding is projected to rise in many countries. This rise has two main causes. Firstly, global climate change causes more extreme weather events. The Intergovernmental Panel on Climate Change (IPCC) expects a general tendency of more extreme rainfall events (Hegerl et al., 2007). In Europe, the effect of global climate change causes different trends for every region, but generally, the frequency and intensity of flood events caused by extreme weather are likely to rise (Dankers & Feyen, 2008; Madsen et al., 2014; Neslen, 2017; Mitchell, 2003). The second cause of a projected rise in flood risk is of a socioeconomic nature. Economic development leads to a higher value of properties that are vulnerable to floods, which causes the potential damage of a flood to rise (Hinkel et al., 2014). The height of the annual damage in combination with the lethal threat of floods and the growing flood risk, demand action to lower the flood risk.

1.2 Flood Resilience

Action is required to prevent floods. This action can take many forms. Spatial measures can be taken to relocate vulnerable objects that are valuable to society, to make sure these objects cannot be flooded (Hegger et al., 2016). Some objects are impossible or simply too costly to relocate, however. Structural measures can be taken to increase the safety of the existing structures in endangered areas. Dikes, dams and other structural

measures can enlarge the capacity of the waterworks, but a complete elimination of flood risks cannot be achieved. High costs and the inherent uncertainty of floods make absolute protection unachievable (Schanze, 2006).

Despite the unattainability of absolute protection, society has to act to lower the devastating consequences of future floods. To do this, society has to become more (flood) resilient. Resilience is a multi-interpretable term that has been used in many fields (e.g. in ecology (Holling, 1973), in political science (Joseph, 2013) and in psychology (Rutter, 1987)). In all these respective fields, it has the same intention, namely that the subject of stress can withstand and adapt to the stress whilst not being harmed in its functionality (Restemeyer, Woltjer & van den Brink, 2015: p. 47). Societal flood resilience can therefore be defined as `*the ability of a community in a flood prone region to withstand and adapt to stress whilst not being harmed in its functionality*`. The flood risk needs to be minimalised to improve flood resilience.

A flood risk consists of two aspects: the probability of the occurrence of a flood and the vulnerability of the flood prone area, which includes the value of the area (Merz et al., 2010). Resilience is a concept that includes both the probability and the vulnerability part of the flood risk equation (Schelfaut et al., 2009). The probability of the occurrence of a flood is determined by examining the capacity of the local measures. Structural measures, such as dikes and dams have a maximum capacity of water they can counter (Bründl et al., 2009). If the water level exceeds this maximum capacity, the area behind the measures becomes inundated. New or improved structural measures can lower the flood risk by heightening the maximum capacity of the combination of flood measures. Another solution to lower the flood probability is by relocating infrastructure away from vulnerable areas, preventing inundation from being called a flood, as there is no property to be damaged (Hegger et al., 2016).

The vulnerability of an area is determined by the economic value of properties that can be damaged by the water in combination with the likelihood of people being in danger in the flood prone area. Multiple measures can be taken to lower the vulnerability of an area (Merz et al., 2010). Firstly, not locating valuable assets in flood prone areas is a simple but useful tactic to lower flood risks. Valuable assets can also be defended by placing them upon pillars or by other local protection (Bründl et al., 2009). Secondly, emergency channels can be dug to prevent a flood event from flooding the entire area. Instead of an unmanaged flood, a specifically determined fraction of the endangered area can be inundated. Thirdly, the safety of the local people can be ensured by forming evacuation plans and educating the local people about the risks of living in a flood prone area.

Different conceptualisations of flood resilience can be found in the international scholarly literature (e.g. Restemeyer, Woltjer & van den Brink, 2015; Alexander, 2013; Alexander, Priest & Mees, 2016). All of these conceptualisations focus on the same three dimensions of (societal) flood resilience, but the terminology often differs. This research will focus on the same three dimensions, which together lead to societal flood resilience: robustness (also called persistence or resistance), adaptability (also called capacity to absorb and recover) and transformability (Folke et al., 2010; Galderisi & Ferrarra, 2012; Restemeyer, Woltjer & van den Brink, 2015; Davoudi et al., 2012; Alexander, Priest & Mees, 2016).

The term `*robustness*` is used to describe the societal capacity to prevent floods from occurring. Robustness can be achieved by lowering the likelihood of flooding (Restemeyer, Woltjer & van den Brink, 2015). Examples of measures that can be applied to increase the robustness of society are structural measures such

as dams and dikes. Such measures expand the capacity of the flood works, which lowers the flood risk. The term `*adaptability*` is used to describe the societal capacity to lower the potential damage of floods (the lowering of the vulnerability to a flood). The societal capacity to lower the potential damage can be stimulated by local measures that protect valuable objects. Other measures that could increase the adaptability include the formation of evacuation plans, giving the waterways more space and renaturalisation projects. The term `*transformability*` is used to describe the capacity to transform society to be able to cope with future (flood) challenges. The transformability of a society is hard to measure, as it focusses on future challenges, which are hard to predict. The manner in which uncertainty has been taken into account in the decision-making process is a good indicator of the transformability of a society. A further explanation of the different dimensions of societal flood resilience follows in chapter two.

1.3 Flood Risk Management

Flood resilience is a desirable condition for a society as it improves the safety and stability of a society. Flood management is the governmental occupation that attempts to make society more flood resilient. Traditionally flood management was solely focussed on the reduction of flood probability. Structural measures were taken to lower the probability of a flood (Merz et al., 2010; Schelfaut et al., 2009). Managing floods with a sole focus on structural measures has been around for centuries and is called 'flood protection' (Schanze, 2006).

A series of events including the 1993 and 1995 near-floods in the Netherlands and the 2004 tsunami in Indonesia made the international scientific community and flood management practitioners aware that some floods cannot be prevented (Meijerink, 2005; Schanze, 2006). More and more experts are realising that a complete eradication of the possibility of flooding is proving to be unattainable. This results in the understanding that the attention needs to shift from a narrow focus on structural flood management to a broader approach including adaptability and transformability to lower the potential damage of unpreventable floods. This more diversified approach that aspires to include all aspects of flood resilience is called (holistic) Flood Risk Management (FRM) (Merz et al., 2010). FRM focusses on a broader strategy of managing flood risks, including the alleviation of damage by flood mitigation, flood preparation and recovery measures (Hegger et al. 2016). FRM thereby includes all aspects (robustness, adaptability and transformability) of flood resilience, which is explained in the theoretical framework in chapter two.

The shifting focus towards holistic FRM policy has attracted considerable academic attention. Its implementation has been studied in urban environments (Restemeyer, Woltjer & van den Brink, 2015) and on an international level (Hegger et al. 2016). Restemeyer, Woltjer & van den Brink did research into the flood resilience concept in the North-German city of Hamburg (2015). The researchers argued for a shift towards a more flood resilient city, including adaptability and transformability as key components. The stakeholders in the city suggested flood resilience not to be a goal of its own but argued for flood resilience as a part of the bigger urban agenda. Hegger et al. evaluated the flood management policy of five European countries (2016). Their research, the STAR-flood consortium, was funded by the European Union. The evaluation of the flood management policy in five EU member states brought insights into the differences between countries. An example of an insight stemming from this comparison is that the Netherlands focusses more on Robustness (structural measures) whereas the United Kingdom focusses more on adaptability (insurance and evacuation). The comparison between the countries can bring lessons for the 'less flood resilient member states'. None of the described research focusses on rural mountainous areas, however. This research aims to close this gap by looking into FRM policy in a mountainous area in Switzerland.

1.4 Floods in Switzerland

This research will be conducted in Switzerland, because Switzerland has (at least) four interesting characteristics that make its flood management policy different from flood management policies in previous studies. Firstly, Switzerland is a federal state, which means the national government has little power when it comes to the implementation of local policies (Vischer, 2003). The decentralised power makes the local decision-makers responsible for the complete array of FRM policy (see chapter 4). These local actors are the main stakeholders in the whole FRM policy domain. This research will give insights into the way local actors deal with this grand responsibility. The second characteristic is that Switzerland has a long history of FRM policy, dating back to the beginning of the 18th century (Summermatter, 2012). This heritage has a lot of impact on the way floods are seen and dealt with by the responsible actors today. Thirdly, Switzerland has interesting geographical characteristics, with many isolated mountainous areas (Summermatter, 2012). This is a very important detail as this research focusses on FRM in such areas. Lastly, Switzerland is likely to encounter negative consequences of climate change, which makes a more holistic FRM policy essential for society to thrive (Beniston et al., 1994; Elsasser & Bürki, 2002).

Switzerland is not internationally known for its flood catastrophes; however it has been scourged by flood events in the past. In August 2005 for example, Switzerland was hit by a major flood with unprecedented consequences. Extreme rainfall came down on the North side of the Alps, causing creeks to turn into muddy rivers, cities into lakes and hangs into apocalyptic mud streams. Six people lost their lives in the extreme flood event and the total material damage in Switzerland is estimated to be between 1.8 and 3 billion Swiss Francs (BAFU, 2008; Hilker, Badoux & Hegg, 2009). The rainfall in this particular instance was extreme, but similar events are likely to happen in the future and Switzerland needs to prepare itself, to make sure the impact will never be this big again (Hilker, Badoux & Hegg, 2009).

The 2005 floods were not the only catastrophe that involved flooding in Switzerland. Floods were the cause of 124 fatalities in Switzerland between 1946 and 2015 (Badoux et al., 2016). Floods thereby accounted for over 12 per cent of all fatalities caused by natural hazards in the country. This percentage seems relatively limited, considering the fact that snow avalanches are the cause of 37 per cent of Swiss natural hazard fatalities. Flood fatalities do not include extreme risk sports such as skiing however, meaning that the victims did not choose to take risks and the natural hazard could indeed potentially endanger every citizen in Switzerland. The total damage caused by floods in Switzerland in the timespan between 1972 and 2007 has cost the country a staggering seven billion euros (Hilker, Badoux & Hegg, 2009: p. 917). On average the annual damage of floods in Switzerland is circa 200 million euros.

The flood damage in Switzerland can be categorised in three categories: material assets, infrastructure and forestry/agriculture. Material assets, such as houses, cars and factories are by far the most affected category (80%) followed by infrastructure (18%) and forestry/agriculture (2%) (Hilker, Badoux & Hegg, 2009: p. 918). The central alpine region in Switzerland is the most affected region of floods in Switzerland.

The developments that cause a higher flood risk can also be identified in the Swiss Alps. The Swiss economy is growing at a pace of two per cent per year, raising the potential damage of floods (Seco, 2018). Climate change also has an effect on this region, as climate change will change the external circumstances in rural mountainous areas. In the Alps, climate change is likely to cause warmer and drier summers and warmer and wetter winters, where more precipitation will come down in the form of rain instead of snow (Müller &

Weber, 2007; Walther et al.,2002). Furthermore, more peak rains are likely to occur. These developments can lead to more floods similar to the 2005 floods (Summermatter, 2012; Barben, 2014). If Switzerland does not respond to these developments, the damage can potentially be very high.

According to the Swiss government, three steps have to be taken to achieve flood resilience through holistic FRM policy (PLANAT, 2004; p. 24). Firstly, the flood risk has to be identified and analysed. This analysis looks at records of historic catastrophes and analyses the landscape. Secondly, the scale of the protection goals has to be established. These protection goals are to be defined using economic value and presence of people. Lastly, the measures that can and will be taken have to be defined and realised to reach these goals. This roadmap for Swiss FRM appears to include elements that ensure flood resilience by promoting the robustness, adaptability and transformability of the Swiss society. Whether the shift from a narrow focus on flood protection towards (holistic) FRM (including all aspects of flood resilience), is visible on a local scale in Switzerland is unconfirmed, and forms the goal of this research.

One region in which the potential damage of floods is high is the Bernese Oberland. The majority of municipalities in this region suffered damages of over 5 million euros in the period between 1972 and 2007, whereas the vast majority of municipalities in Switzerland have not suffered damages of over 1 million in the same timespan (Hilker, Badoux & Hegg, 2009: p. 919). This region needs to move towards flood resilience through a complete and holistic FRM policy, to ensure the future safety of its inhabitants. This research evaluates to what extent the current local flood management policy in action, called the Flood Risk Governance Arrangement (FRGA), is holistic. The FRGA includes the institutional structure and processes that guide and restrain collective activities of a society to regulate, reduce or control risks (Kaufmann, 2017; p. 107). The FRGA is seen as holistic if it includes the different dimensions of flood resilience that come forth from the international scholarly literature (see chapter two).

1.5 Research Questions

The main aim of this research is to evaluate all aspects of the FRGA in mountainous river catchments in the Bernese Oberland to assess if a holistic FRM policy is in place that supports the flood resilience of the area. To structurally assess the policies as completely as possible, three specific river catchments have been selected: the Hasli-Aare-, the Lütschine- and the Kander river catchments.

The previous paragraphs show that (holistic) FRM policy is recognised as a means to ensure a safe living environment. Holistic FRM policy in this research includes three dimensions of flood resilience: robustness, adaptability and transformability. At the basis of this research lies the assumption that a complete and holistic FRM policy, with a focus on all three dimensions of flood resilience induces a safe living environment. This assumption can be logically argued but cannot (yet) be defended with empirical evidence. This research evaluates to what extent holistic FRM policy is adequately implemented in the three river catchments in the Bernese Oberland.

The flood resilience of the local FRGA is evaluated using the following research question:

`What dimensions of flood resilience are supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`

This main research question is divided into three sub questions, in order to help structure the research. The sub questions focus on the different dimensions of flood resilience:

- `To what extent is *robustness* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`

- `To what extent is *adaptability* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`

- `To what extent is *transformability* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`

The answers of the three sub questions form an in-depth evaluation of the FRGA in the three river catchments in the Bernese Oberland. The answers to the sub questions are qualitatively assessed, which leads to a description of the supporting and constraining aspects of the current FRGA in the Bernese Oberland.

This Master's thesis has become a large body of work. The following guidance is meant to help understand its structure. The first chapter has shown the problem at hand, the danger of floods in mountainous areas. It has also shown the questions that will be answered in the rest of this document. The final two paragraphs of this chapter will show the significance of this research to society and to the scientific community. Chapter two shows how these questions are embedded in the international scholarly literature on FRM. Chapter three gives an explanation of the means that have been used to answer the questions. It also shows why these means seemed appropriate to the researcher. Chapter four is an extra chapter, that is not included in most Master's theses, but which was requested by Dutch readers to allow them to understand the context of this study. This chapter is common knowledge for Swiss readers and can be skipped. Chapters five, six and seven form the main body of this research. These chapters describe and analyse the FRGA, structured by the theoretical foundation stemming from chapter two and three. Chapter eight finally answers the research question and sub questions. Chapter nine discusses these answers, puts them into perspective and shows the limits of this research.

1.6 Societal Relevance

This Master's thesis is an academic work, but it also means to have a societal impact. The local people in the Bernese Oberland are the main beneficiaries of a functioning FRGA that promotes flood resilience as holistically as possible. The 2005 floods are one example of the damage floods can do to the Swiss society. The damage was not solely of a material nature, but left emotional marks as well (BAFU, 2008). The FRGA ought to prevent similar disasters in the future, or at least limit their consequences. This thesis has evaluated the quality of the FRGA that is currently in place in the mountainous area of the Bernese Oberland. It shows the weaknesses of the FRGA and can thereby help the local experts to promote the safety of the local community.

This evaluative research is urgently required because both economic expansion and climate change cause the flood risk to rise in the area, if nothing is done to lower it (Seco, 2018; Müller & Weber, 2007; Walther et al., 2002; BAFU, 2008). These developments threaten the society in the case study and this research means to support local experts to shield their society against a growing flood risk. Communities in the Swiss Alps need

up-to-date flood resilience measures in order to be prepared for future extreme weather events. These future events are impossible to predict and have the potential to be bigger than the 2005 floods.

The evaluation of the current state of the FRGA helps local policy-makers to identify the strengths as well as the weaknesses of their current policy. The evaluation can thereby help clarify which changes are necessary to the current local FRGA, in order to make the local community as prepared as possible for future challenges.

The evaluation of the different dimensions of flood resilience gives a clear overview of the current state of the flood protection in the area. It shows that there are some differences within the studied area, giving local flood risk practitioners the opportunity to learn from other parts of the studied area. The opportunity of learning from the more innovative parts of the area helps the less developed areas to become safer. These are the areas that most urgently need to become safer and that simultaneously can benefit from the results of this study the most. In the end, this evaluative study tries to guide local governmental bodies to overcome their weaknesses to make the local people safer.

1.7 Scientific Relevance

This study does not only help the Swiss people, it can also benefit the scientific community. Flood resilience is a concept that has been studied intensively on an international level (e.g. the STAR-FLOOD research, see Hegger et al. 2016) and in the urban society (e.g. Restemeyer, Woltjer and van den Brink, 2015; Aerts et al., 2014). These studies have formed and used promising evaluative frameworks that can be applied to different circumstances. This Master's thesis has applied the theory of flood resilience to rural mountainous circumstances, to which it had not yet been applied.

All of the aforementioned studies focus either on coastal areas or on urban areas, whereas the academic literature on flood resilience in rural and mountainous areas in Europe is very limited. The high damage that has been recorded in Switzerland suggests that flood resilience is difficult in Switzerland and this difficulty might stem from the geographical characteristics (Brouwer, Huitema & Aerts, 2007). Communities in mountainous areas are potentially less resilient because of the low manageability of mountainous rivers as suggested by Buchecker, Ogasa and Maidl (2016). Some measures, like accommodating water might also be difficult due to the amount of rocks in flooding mountain rivers. Another difficulty for reaching flood resilience is the low population density, which could lower the height of investments for FRM measures. These suggested phenomena generate a lot of interesting side notes to the intended aim of the study.

The gap in literature when it comes to flood resilience in rural and mountainous areas is the exact niche in which this study can be found. This research can be seen as a first exploration of that niche. It uses similar criteria that have been used in FRM studies in other geographical circumstances and can thereby reveal differences that have previously been unknown to the scientific field of qualitative water management.

Ergo, evaluating flood resilience in mountainous areas, such as the Bernese Oberland can give a clear insight into the effects of geographical characteristics on flood resilience in the FRGA. The case study, the Bernese Oberland, is unique in its characteristics, as Switzerland is a federal state with different policies in every canton. On top of this, the ontological and epistemological foundations of this research reveal a focus on the specific social situation of the Bernese Oberland today. The results of this study are therefore likely to differ from other parts of the Swiss Alps and per extension from other mountainous areas. The generalisability of

the conclusions is thereby very limited, but some insights that can be derived from this Master's thesis, such as the influence of mountainous geographical circumstances and a direct federal democracy on the FRGA, will help future researchers towards a better understanding of flood resilience.

Chapter 2: Theoretical Framework

The questions that have been posed in the previous chapter do not stand alone. The scientific world is an interconnected web of different questions and answers that in some way overlap. It can therefore be argued that a thesis, without a formulation of the theoretical context on which it is based, is useless (Diefenbach, 2008; p. 878). This chapter outlines the theoretical foundations on which this thesis is built, in order to explicate its place within the scientific field. It does so by outlining the trends in the field of quantitative water management and by summarising the previous scientific theories on the main dimensions of flood resilience.

2.1 From Flood Management to Flood Risk Management

Flood management used to consist solely of defensive and preventative measures. All measures were initiated by the state, making it a part of public policy. This form of preventing floods is often defined as flood prevention. As shown in the introduction, the focus of flood management has shifted, both in the scientific literature and in practice (Merz et al., 2010; Butler & Pidgeon, 2011). Since the second half of the 20th century, the sole focus on flood management became too narrow as the realisation came that some floods cannot be prevented (Summermatter, 2012). The amount and severity in which a certain part of the world was struck by floods defined the speed at which this realisation is turned into action (Meijerink, 2005). These days, most flood risk practitioners and scholars agree that the focus of flood risk management should include both prevention of, and adaptation to flood risks.

In Switzerland several big flood events have occurred, causing a similar shifting focus from flood management to (holistic) flood management (Summermatter, 2012). In the middle of the 20th century Swiss flood risk practitioners started to doubt whether floods in Switzerland could really be prevented at all times without changing the locations of many Swiss villages and towns. The big floods of 1987, that struck villages throughout the country, proved that some floods cannot be prevented. The 1987 floods made flood practitioners aware that evacuation plans and other adaptability measures should be available and functional. The extreme floods of 2005 demonstrated that the shift towards holistic flood risk management had not been completed yet and that more changes needed to occur, in order to make Swiss society less vulnerable to floods, ergo to be flood resilient (BAFU, 2008). This chapter shows what flood resilience scholars think flood resilience consists of in theory and how this can be achieved.

Scientists as well as politicians and flood management practitioners in Switzerland now realise that some floods cannot be prevented (Summermatter, 2012). This realisation leads to a shifting focus in new laws and innovative construction projects. Since 2004 Swiss directives include holistic FRM as an important aspect of Swiss natural hazard management (PLANAT, 2004). The Swiss vision on the conceptualisation of holistic FRM consists of three aspects: prevention *('prävention'),* intervention *('intervention')* and recovery/corrective maintenance*('Wiederinstandstellung'*) (PLANAT, 2004; p. 23). These three aspects of FRM are of equal importance (PLANAT, 2004; p. 16). Prevention in this conceptualisation is a synonym for the term robustness (Restemeijer, Woltjer et al., 2015). Intervention is a major component of the adaptability conceptualisation as described before. The third aspect, described by the German word 'Wiederinstandstellung' can be loosely translated as recovery and is thereby closely related to that aspect of the Alexander, Priest and Mees conceptualisation of flood resilience (2015).

2.2 Different Conceptualisations of FRM Theory

The Swiss view on flood resilient FRM theory does not stand alone. Many different conceptualisations can be found in the international scholarly literature. This chapter will give an overview of these different theories on holistic flood risk management. These conceptualisations differ in their exact terminology and in the broadness of their strategy towards flood resilience. The basis of these conceptualisations of holistic FRM does not differ, however. The basic assumption underlying this idea of holistic flood resilience, is that a focus on different strategies towards the same goal (flood resilience) creates a safer society. This assumption is at the core of the different conceptualisations of flood resilience, like it is at the core of this thesis. Three such theories have already been described. A fourth example is the multi-layer safety (MLS) theory, which shows a similarly diffused focus. In the MLS theory, different strategies are available to ensure that if the first fails, the second and third are still available (Tsimpoulou et al., 2013). Ergo, three layers of safety form three different strategies of FRM: Layer one focusses on the prevention of flooding, layer two focusses on spatial solutions for the reduction of losses, and layer three consists of emergency management measures, such as evacuation (p. 2583).

Table 1 shows four conceptualisations of holistic FRM policy. It includes the conceptualisation of Restemeyer, Woltjer and van de Brink (2015), the MLS theory (Tsimpoulou et al., 2013), the STAR-FLOOD approach (Hegger et al., 2016) and the Swiss conceptualisation of flood resilience, written by the Swiss platform on natural hazards (PLANAT, 2004). The STAR-FLOOD approach and the Restemeyer, Woltjer and van den Brink conceptualisations have already been introduced in the introduction (see §1.3). The four conceptualisations differ on the exact terminology, on the broadness of the concept of holistic FRM policy and on the narrowness of the individual strategies or dimensions. These distinctions will be explained in the following paragraphs.

Theoretical Outline of the Different Conceptualisations of Flood Resilience						
Theory	**Limiting Probability of Flooding**		**Limiting Damage of Flooding**			**Fostering Societal Change**
Restemeyer, Woltjer & van den Brink (Restemeyer, Woltjer & van den Brink, 2015)	Robustness		Adaptability			Transformability
Multi-Layer Safety (Tsimpoulou et al., 2013)	Prevention	-	Mitigation	Emergency Planning		-
STAR-FLOOD (Hegger et al., 2016)	Risk Prevention	Flood Defence	Flood Mitigation	Flood Preparation	Flood Recovery	Parts of Flood Mitigation and Recovery

PLANAT (PLANAT, 2004)	'Prävention' (prevention)	'Intervention' (intervention)	'Wiederinstandstellung' (recovery)	-

Table 1: Theoretical Outline

2.3 Flood Resilience and Robustness

Scholars in resilience theory dispute over two different definitions of resilience. Some, like Vis et al. take a strict definition of resilience, which does not include robustness (2003). They claim that robustness is about the reduction of the probability of a risk, whereas resilience is about the alleviation of the potential damage of the risk. Other scholars take a broader definition of resilience (Davoudi et al., 2012, Holling 1973). They consider robustness (or resistance, persistence) as a dimension of resilience, because it is part of the power to withstand outside forces (Restemeyer, Woltjer and van den Brink, 2015). Hegger et al. define flood resilience as "the capacity to resist, absorb, recover and/or adapt to stresses and so-called shock events (2016; p. 2)". They thereby also follow the broad definition of resilience on the dimension of robustness, as they include the capacity to resist stresses. Natural hazard management is based on the premise that to prevent a natural hazard event is better than to cope with one. This is also the reasoning behind the first layer of the MLS approach, and the 'prävention' phase of the PLANAT strategy, which both aim to prevent floods (Tsimpoulou et al., 2013; PLANAT, 2004). The definition of flood resilience used in this thesis is "the ability of a community in a flood prone region to withstand and adapt to stress whilst not being harmed in its functionality." By including `the ability to withstand` into the definition, which encapsulates robustness, this research follows the broad definition of resilience, like Restemeyer, Woltjer and van den Brink (2015) and Hegger et al. (2016). Robustness is therefore a dimension of flood resilience in this research. Table 2 schematically shows the different terminologies for the concept of robustness and is part of the overviewing table 1.

Different conceptualisations of Robustness in the FRM theories		
Theory	**Aspects of Robustness**	
Restemeyer, Woltjer & van den Brink (Restemeyer, Woltjer & van den Brink, 2015)	Robustness (prevention of floods)	
Multi-Layer Safety (Tsimpoulou et al., 2013)	Prevention	-
STAR-FLOOD (Hegger et al., 2016)	Risk Prevention	Flood Defence
PLANAT (PLANAT, 2004)	'Prävention' (prevention)	

Table 2: Theoretical Outline Robustness

Different measures can be taken to attain a robust flood risk management policy. The aim of robustness is to prevent floods from happening. Robustness, as used by Restemeyer, Woltjer and van den Brink is thereby synonymous to the term 'prevention' from the MLS theory and the PLANAT strategy. Hegger et al. distinguishes between two different categories, namely risk prevention and defence measures (2016). The risk prevention strategy focuses on spatial planning (Alexander et al., 2016: p. IV). This strategy strives for a minimisation of people`s exposure to floods. An example of a flood prevention measure is spatial planning policy that prevents further economic development in flood prone areas. This strategy of preventing floods

can also be identified in the description of prevention and in the robustness conceptualisation of Restemeyer, Woltjer & van den Brink. It is not a part of the Multi-layer Safety theory, as this theory only aims to protect existing livelihoods from flood damage, leaving out the option of radical relocations (Tsimpoulou et al., 2013).

The second strategy of the STAR-FLOOD approach, flood defence, focuses on the prevention of floods by structural measures to minimise the magnitude and the likelihood of flooding (Alexander et al., 2016). Floods are prevented in this strategy by building dams, dikes, embankments and demountable defences. This is the strategy which traditional 'flood management' encompasses and is thereby synonymous to both robustness and prevention. The distinction between flood risk prevention through spatial planning and flood risk prevention through defensive measures is clear, as both strategies demand different measures. Although the distinction is clear, the goal of both strategies is identical, namely, to prevent floods from happening. The distinction thereby unnecessarily complicates the theoretical understanding of the concept of flood resilience. This research adopts the dimension 'robustness' to mean all strategies towards the prevention of flood events, including both spatial planning and structural measures. The distinct strategies of flood prevention are useful to evaluate the completeness of the FRGA in practice and are therefore used in this research to solidify and structure the distribution of criteria in the operationalisation.

2.4 Flood Resilience and Adaptability

The second dimension of societal flood resilience is adaptability. Adaptability aims at the reduction of flood vulnerability. It thereby responds to the growing recognition among scholars and policy makers that not all floods can be prevented by defensive or preventive measures (Alexander, Priest and Mees, 2016: p.41). Recent floods in Switzerland have empirically proven this statement (Bründl et al., 2009). To lower the damage of these `unpreventable` floods, adaptability measures are necessary. This includes flood mitigation measures, which try to 'live with the water' or in other words, cope with floods, emergency planning and recovery measures. (Hegger et al., 2016).

Different Conceptualisations of Adaptability in the FRM theories			
Theory	**Aspects of Adaptability**		
Restemeyer, Woltjer & van den Brink (Restemeyer, Woltjer & van den Brink, 2015)	Adaptability (limiting the damage of floods)		
Multi-Layer Safety (Tsimpoulou et al., 2013)	Mitigation	Emergency Planning	
STAR-FLOOD (Hegger et al., 2016)	Flood mitigation	Flood Preparation	Flood Recovery
PLANAT (PLANAT, 2004)	'Intervention' (intervention)	'Wiederinstandstellung' (recovery)	

Table 3: Theoretical Outline Adaptability

The adaptability dimension aims to limit the damage of a flood (Restemeyer, Woltjer & van den Brink, 2015). There are different means to this end. The STAR-FLOOD approach distinguishes between three different strategies that lower the damage of a flood, if that flood cannot be prevented (Hegger et al., 2016). Flood mitigation measures lower the damage by building local flood protection measures such as flood walls in front

of vulnerable houses. Flood preparation measures prepare the local community for a flood event, so they can be evacuated and so they can save their valuable belongings. Flood recovery measures ensure a quick recovery after a flood by i.a. (re-) insurance and community building. The first two strategies certainly lower the damage of floods and therefore belong to the dimension of adaptability. The third strategy, flood recovery, partly lowers the damage of a flood and partly helps society to transform towards a more flood resilient state. It lowers the damage of a flood by making sure the flood event does not have a long-term damaging impact. It helps society transform by rebuilding the society, which likely does not happen in the same way as it was when it went wrong, and can therefore be considered part of the transformability dimension.

The MLS theory incorporates the same two strategies as the STAR-FLOOD approach (Tsimpoulou et al., 2013). Flood mitigation and mitigation are synonyms and so are flood preparation and emergency planning, although flood preparation is a broader strategy with more focus on the education of people. On top of this narrowness of the term 'emergency planning', the MLS theory does not include flood recovery measures. These differences stem from the origin in spatial planning of the MLS theory. The theory is in this regard less holistic than the STAR-FLOOD approach.

The Swiss PLANAT strategy focusses on the limitation of damage of floods by the intervention and recovery strategies (PLANAT, 2004). The intervention strategy is similar to the emergency planning and flood preparation strategies and the recovery strategy is similar to its namesake in the STAR-FLOOD approach (Hegger et al. 2016). The main difference between the PLANAT and the STAR-FLOOD theories, is the fact that mitigation measures are not part of the PLANAT strategy for flood resilience. The structural measures that can be done to limit the impact of floods to the Swiss society all belong to the term 'flood prevention' in the PLANAT strategy. Some structural measures, like local flood walls lower the damage, when a flood does occur. The PLANAT strategy does not include these measures in their theory and is therefore less inclusive than the STAR-FLOOD and Restemeyer, Woltjer and van den Brink theories.

Compared to the other theories, the STAR-FLOOD theory contains the most elaborate approach towards the lowering of the damage of floods (Hegger et al., 2016). Both the mitigation and the preparation measures are important steps towards this goal, and are therefore essential for the complete evaluation of flood resilience in the Bernese Oberland, that is intended in this research. The third strategy, flood recovery only partly aims to lower the damage of floods. The insurance part of this strategy focusses on a quick recovery of the local society which is a part of lowering the damage of floods and is therefore a part of 'adaptability'. The lessons that are drawn from flood events in the past, focus on changing the society and therefore belong to the concept of 'transformability'. As at least parts of all three strategies strive for the same goal, the distinction between them on a theoretical level unnecessarily complexifies the understanding of the concept. Therefore this research will use the term 'adaptability' as used by Restemeyer, Woltjer and van den Brink to mean all strategies towards the alleviation of flood damage. In the operationalisation, the distinct strategies towards this goal have been included to form evaluation criteria.

2.5 Flood Resilience and Transformability

The third and last dimension of societal flood resilience according to Restemeyer, Woltjer and van den Brink is transformability (2015). Transformability as a dimension of flood resilience is defined as the ability to foster societal change (Restemeyer, Woltjer & van den Brink, 2015: p.8). If a region aims to be flood resilient over a longer period, it will need to adapt to the changing circumstances in a sustainable manner. Developments,

such as climate change and socio- economic development will change the circumstances of a region. Still, the focus on transformability is limited in the international scholarly literature on flood risk management. The author of this research advocates more focus on the fostering of societal change. Multiple reasons to stress the importance of societal change exist.

Focussing on societal change in FRM policy is important for various reasons. The most important of which is that societal change is the main way to become more flood resilient within the current societal trends. One of these trends is the change from flood management to flood risk management as described in the introduction and in §2.1 (Merz et al., 2010). The traditional focus on flood defence (robustness) is a governmental endeavour. The shifting focus towards adaptability, requires more effort of private individuals, to make them see the importance of i.a. local protection and evacuation plans. Societal change is required to make them see the importance of these matters. Another trend that stresses the importance of societal change is the rising of the bottom-up approach(O'Toole, 2000). This trend, where the traditional top-down way of starting new initiatives is replaced by initiatives of private individuals. This trends also gives the local people power and thereby responsibility, which leads to awareness (see §2.7). On top of these societal trends, an important reason for societal change to be important is that climate change and other future challenges cause uncertainty and thereby require society to be flexible. These uncertainties are called 'deep uncertainties' in the scholarly literature and demand special attention (Buurman & Babovic, 2017). These arguments show that transformability is essential to flood resilience and will be given the attention it demands in this research.

Restemeyer. Woltjer & van den Brink deem transformability one of the three dimensions of flood resilience, and thereby focus a lot of attention on the subject (2015). Hegger et al. do not put as much emphasis on transformability, although aspects of societal change can be found if the theory is examined closely (2016). They do mention `learning` and implementing `lessons learnt` as goals towards flood resilience. Alexander, Priest and Mees (part of the STAR-FLOOD consortium) talk about the capacity to adapt, but parts of this adaptation can be considered a part of the concept of transformability, rather than the concept of adaptability (2016). Whereas adaptability in the last paragraph is specified as the means to lower the damage of a potential flood, Alexander, Priest and Mees see the capacity to adapt as the need to learn, experiment, innovate and deal with the uncertainties of the future (2016: p. 40). Their conceptualisation of the capacity to adapt therefore falls under Restemeyer, Woltjer and van den Brink`s conceptualisation of transformability, as it aspires to transform societal thinking to include potential future dangers (2015).

Transformability tries to reach societal change by changing the mind-set and the behaviour of the people, to make them understand that flooding is a real risk, for which they need to be prepared. Transformability is necessary, as the research by Buchecker, Ogasa & Maidl has shown that the local Swiss people still trust on the traditional structural measures, that cannot prevent every flood (2016). Measures that can improve transformability are risk communication and awareness raising among private and public stakeholders. Brochures, public campaigns, education, participatory governance tools and consensus building are means to achieve this goal.

2.6 Flood Resilience Conceptualised

The previous paragraphs have compared four different theories on holistic FRM policy. Holistic FRM needs to include measures that focus on flood probability reduction (robustness), flood vulnerability reduction (adaptability) and that foster societal change (transformability). If all three forms of measures are combined in

a balanced way, the local society will be optimally flood resilient and thereby as safe as possible. Complete eradication of the flood risk will remain unachievable, however. Holistic FRM policy strives for a balanced and optimal policy towards flood resilience. Figure 1 visually presents this conceptualisation of flood resilience.

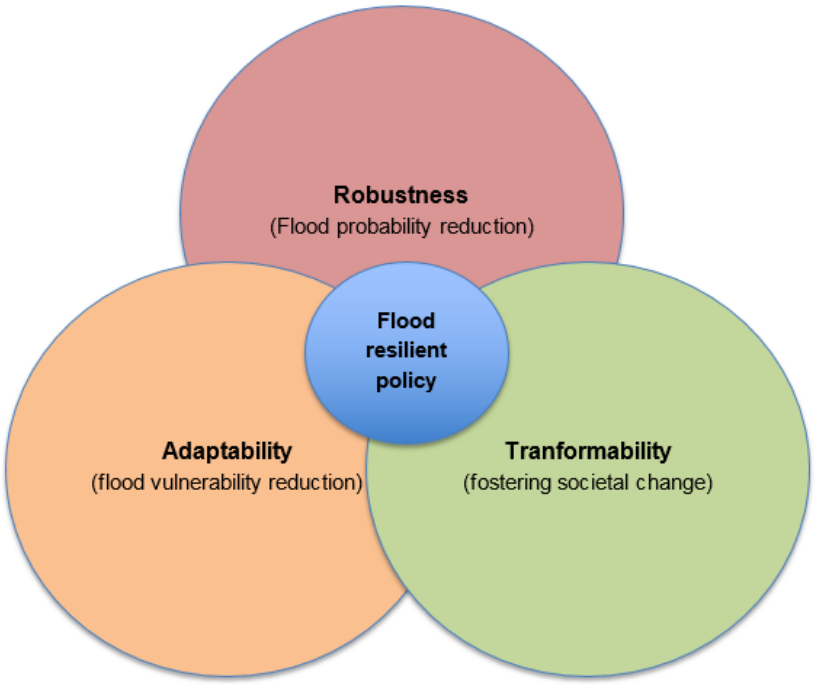

Figure 1: Conceptual framework of flood resilient FRM policy

The aim of this research is to evaluate the FRGA in mountainous river catchments in the Bernese Oberland on flood resilience. If the FRGA in this area can be considered flood resilient, that means the policy aims for flood probability reduction, flood vulnerability reduction as well as fostering societal change. If the local FRGA is considered to be flood resilient, it would be evaluated as being in the blue circle in the middle of figure 1. This shows the underlying assumption that the more robust, adaptable and transformable the FRGA is, the more optimally balanced and thereby flood resilient the FRGA is.

2.7 Implementation Research as Part of Policy Analysis Research

The goal of this thesis is to assess to what extent a certain policy (holistic flood risk management policy) has been implemented in a certain area (the Bernese Oberland). This section of the theory shows what it means for a policy to be implemented. In the policy analysis research field this is defined as 'policy turned into action' (Pülz & Treib, 2006; p. 89). Policy implementation research emerged in the 1970s in America. The emergence of the field evolved with the realisation that even though policies were formed, they were not always implemented or were interpreted differently than intended. The first generation of implementation policy scholars created awareness for this problem. The second generation of policy implementation scholars (1975-1985) disputed whether policy ought to be hierarchically imposed (top-down approach) or should be started at the lower level and work its way up (bottom-up approach). The third and most recent generation of policy implementation scholars have tried to bridge the gap between these two approaches and have tried to

form a 'hybrid' approach with room for both bottom-up initiatives and top-down structuring (O'Toole, 2000). The most recent studies on policy implementation have moved beyond the traditional top-down/bottom-up discussion (O'Toole, 2000). This transition is in line with the idea of 'governance', where countries are ruled by both governments and local people.

2.8 The Policy Arrangement Approach (PAA)

The federal PLANAT has developed an outline for the local flood risk practitioners to work out (2004). Many different factors impact the depth to which this holistic flood resilience approach has penetrated the local flood risk governance arrangements. Multiple approaches exist to investigate these changes in the FRGA in the Bernese Oberland. Options to investigate the changes include, but are not limited to, the Penetrated Equilibrium theory, Rational Choice theory and the Multiple Streams framework (Sabatier, 2014). This research tries to establish to what extent the different forms of progress considered in the overarching term 'flood resilience' can (already) be identified within the local FRGA. The theories that have just been named are unsuitable for the qualitative analysis of the FRGA, which is the aim of this research (see 3.2). However, a theory is required as a fundament for the analysis, that is the main body of this research, to be able to grasp the complexity of the local situation and to form the basis for the analysis.

Theory is required to give an outline of the most important factors that impact flood resilience policy. It has to focus on flood risk management policy in action, (the FRGA) (Kaufmann, 2017; p. 82). To analyse the FRGA, this research uses the Policy Arrangement Approach (PAA), because the PAA clearly sets out all dimensions of the policy arrangement that impact the FRGA, whilst acknowledging its complexity (Veenman, Liefferink & Arts, 2009). The term 'policy arrangement' that is at the core of this theory is defined as "a temporary stabilisation of a particular policy domain (Leroy & Arts, 2006; p. 13)". The policy domain in this research is that of flood risk management. The PAA focusses on four distinct dimensions that determine the policy (change). These dimensions dictate where the focus of the analysis of this research needs to be. It is important to note that the dimensions are all interrelated and can therefore not be analysed separately (Leroy & Arts, 2006).

The four dimensions that define the policy arrangement and that form the basis of the PAA are 'discourses', 'rules', 'actors' and 'resources' (Kaufmann, 2017). The discourse dimension considers how language, both spoken and written, enacts social and cultural perspectives on the local FRGA (Gee, 2004). The mapping of this discursive dimension looks at the ideas, principles and objectives within the different components of the flood resilience policy in the case study (Kaufmann, 2017; p. 83). As the name suggests, the 'rules' dimension describes the formal and informal laws, regulations and routines that impact the FRGA in the case study. The actor dimension focusses on the role the different actors play in the local formation and implementation of the flood resilience theory. Finally, the 'resources' (or 'power') describes the way in which different forms of available resources are distributed in the governance of the local waterways. The PAA is an analytical tool that helps to map and describe policy practices (Arts & Goverde, 2006). It is not applicable for evaluative research itself. The theory is only used to show the different dimensions of 'policy arrangements' that are evaluated in this research. The PAA has therefore mainly been used in the theoretical and methodological sections to map the different dimensions. The analysis section inevitably focusses on all four dimensions, without assuming distinction between them, as this would feign a simplicity that potentially restrains the depth of the analysis.

Chapter 3: Methodology

The set of questions that form the main objective of this Master's thesis has been posed in the introduction and their theoretical foundation has been constructed in the previous chapter. Chapter three discloses how this thesis means to answer the questions that have previously been posed and contextualised. It starts with the basic assumptions that underly the research, followed by the research design and its ramifications. The chapter concludes with the merits and the limits of this research design.

3.1 Ontological and Epistemological Considerations

The research questions have been defined in the previous chapters, but the manner in which they are deemed to be answered depends on the scientific considerations of knowledge and reality and is thereby inevitably dependent on the researcher (Diefenbach, 2009). Floods are events in which water flows in places where society does not want the water to flow. This is not a 'natural' fact, but an interpretation of reality. Similarly, flood management is based on the premise that a flood is a 'bad' thing and that it therefore has to be 'managed' (prevented, or at least restricted in its consequences). Ancient civilisations like the Egyptians needed floods to ensure the fertility of their lands, viewing floods as necessary and thereby as 'good'. This example shows the subjectivity of the premise on which the entire area of research is based. The fundament of the research is socially constructed and can therefore have multiple interpretations of the truth (Hennink, Hutter and Bailey, 2011). This thesis is based on the understanding that only through the human understanding a flood can be defined, which is regarded as the idealist ontology (Bryman, 2016).

The reasoning that demonstrates this research to be 'idealist' also shows that the knowledge on the management of floods comes from the people's understanding of natural phenomena, instead of the natural phenomena themselves. Similarly, this reasoning shows that this research is based on the interpretivist or constructivist epistemology, which states that interpretivists believe that "reality is constructed by social actors and people's perceptions of [reality] (Wahyuni, 2012; p. 71)". This has major implications for the research. First and foremost, the data that has been acquired does not give an objective representation of the reality of the case study. Rather it is subjected to the understanding of interviewees and even of the researcher. As these humans have different understandings of the world they live in, and their understanding can change with time, the final results of a study on the current situation of FRM in the Bernese Oberland is (only) a 'snapshot' of reality. Similar research done at another moment in time, in a different place or even with different interviewees and researchers is likely to produce different results. Axiologically, the researcher in the constructivist epistemology is inevitably part of the research (Wahyuni, 2012; p. 70). The research is subject to the values of the researcher. However, by explicitly explaining the values that are at the core of this research, the validity of this research does not suffer from the subjective nature of the research, as it gives a complete understanding of the unit of analysis (the FRGA (structured by the PAA)) on a structured basis (the theory) and with a complete explanation of all the premises (methodology) on which it is based (Ness, 2015). It does however, affect the generalisability of the research. As different circumstances and different interviewers and interviewees would produce different results, the results do not implicate any results on different contexts (Diefenbach, 2009; p. 878).

3.2 Qualitative Research

The goal of this Master's thesis is to find an answer to the research question: `What dimensions of flood resilience are supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?` The question implicates certain choices for the decisions that have been made for the research design of this Master's thesis. It does not suggest that this research is of a qualitative nature, however. The research is of a qualitative nature for various reasons. The most important reason for this research design decision is that a qualitative research design follows logically from the constructivist epistemology that is, as explained in the previous paragraph, at its core (Creswell & Creswell, 2017). If the goal of the research is not to strive for objective facts, sec numbers will not allow for a better understanding of the social construct that is under investigation. Another important reason to choose for qualitative research is that the local problem of flood risks is a wicked problem that cannot easily be grasped into plain numbers (Rittel & Webber, 1973). Various details of flood risks on a local level indicate the 'wickedness' of the problem. The damage of flooding is too severe to be able to find the best solution through trial and error. The local decision makers that are responsible for the implementation of the flood measures therefore have no right to be wrong. On top of that flood management is a very complex occupation that is intertwined with multiple other fields such as infrastructure and economics.

The fact that flood management is a wicked problem makes a qualitative research design more suited as a means to answer the research question, because numerical analyses cannot grasp the complexity of the local decision-making. Another argument on which the decision for a qualitative research design is based is the lack of theory on flood management in rural mountainous areas. Some factors that are important in mountainous areas cannot be found in the 'general' FRM literature. These factors can be very important to the local actors and have therefore been included in the research design. As the research focusses on the formation or extension of theory, a qualitative research design is fitting (Bryman, 2016: p. 32). The qualitative research design has some major advantages. It has proven to be able to create an overview of the local system of flood risk management. With this understanding of the subject and its components, of which some are not to be found in the international scholarly literature, a thorough evaluation can be made of all aspects of local flood risk management in the case study region.

3.3 Case Study Research

The qualitative research design that has been used in this research is the case study design. According to Yin (2003) a case study design can be considered suitable when one of the following four criteria is met: (1) It is the appropriate design when it is to answer "how" and "why" questions. The research question is not literally a 'how' or 'why' question, but it can be summarised as 'how is flood resilience stimulated or constrained by the local FRGA in the case study?' Therefore this criterion, put forth by Yin is at least partially met. (2) The behaviour of the involved actors cannot be manipulated. The FRM policy in the case study has been under construction for ages and has cost billions of Swiss Francs, so the way the FRM policy is managed cannot and will not massively be changed by this study (Summermatter, 2012). However, small changes in the way the local experts view the food risk management in the area might slightly change. (3) The study wants to cover contextual conditions because these conditions are believed to be relevant to the phenomenon under study. The contextual conditions, those of a rural mountainous area, are at the core of this study and are believed to be essential to the way in which flood risks are viewed in the case study. (4) The boundaries between the phenomenon and context are not clear. Flood resilience is not solely a manmade defence against floods, but

also contains contextual factors such as the altitude of the landscape and the variability of the climate. These contextual factors can therefore not be seen as external but have to be considered in the decision making and in the research on the decision making. At least three of the four criteria for case study research are met, whereas only one met criterion would already have sufficed. Furthermore, a case study is a good tool to do evaluative research, because it can give information of an ongoing process, it is able to adapt to different types of available information and it can reveal insights that are generalisable in the research field (Yin, 1992: p. 137). In this case the generalisability is limited, as explained in §1.6.

The choice for a case study has proven to be fitting, considering the aim of this research. The research question even demands a certain form of case study. The research question `What dimensions of flood resilience are supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?', already specifies that the research deals with a single region and thereby a (rather big) single case study (Harling, 2012). The research question furthermore specifies that the research looks into a certain phenomenon, namely the focus on flood resilience in a mountainous area. The case study thereby serves as an instrument to create a better understanding of a phenomenon, by showing a complete 'snap-shot' of the current FRM policy in the Bernese Oberland. The specific case study design is thereby the 'instrumental (single) case study' design. The instrumental case study is done to provide a general understanding of a phenomenon (the promotion of flood resilience in mountainous areas) using a particular case (the Bernese Oberland) (Harling, 2012; p. 2).

A case study is capable of giving a detailed and in-depth insight into the flood resilience of the local FRGA in mountainous river catchments in the Bernese Oberland. Local circumstances such as leadership, landscape, population level and flood events in the past can have an impact on the results, but the focus on flood resilience is not limited to the Bernese Oberland, which limits the typicality of the case study (Buckecker, Ogasa & Maidl., 2016; Harling, 2012). This research focuses on three river catchments within one region to increase the robustness and thereby the reliability of the results (Bryman, 2016: p. 156).

3.4 The Case Study

The last paragraphs describe the research design choices that were made to answer the research question. These research design choices are now to be put into practice. The aim of this research is to evaluate FRM policy in a mountainous river catchment in Switzerland on flood resilience. Therefore a case study was to be found that contains a mountainous river stream and that has encountered floods in the past. If no floods have occurred in the case study area in the past, there would not be a need for flood resilience, making this study irrelevant. Furthermore, the instrumental single case study design requires the case study to be located in a single region, with similar governmental and geographical characteristics applying to the entire case study (Harling, 2012). The case studies therefore require 1) to be located in a mountainous area 2) to have encountered floods in the past 3) to be located in similar circumstances.

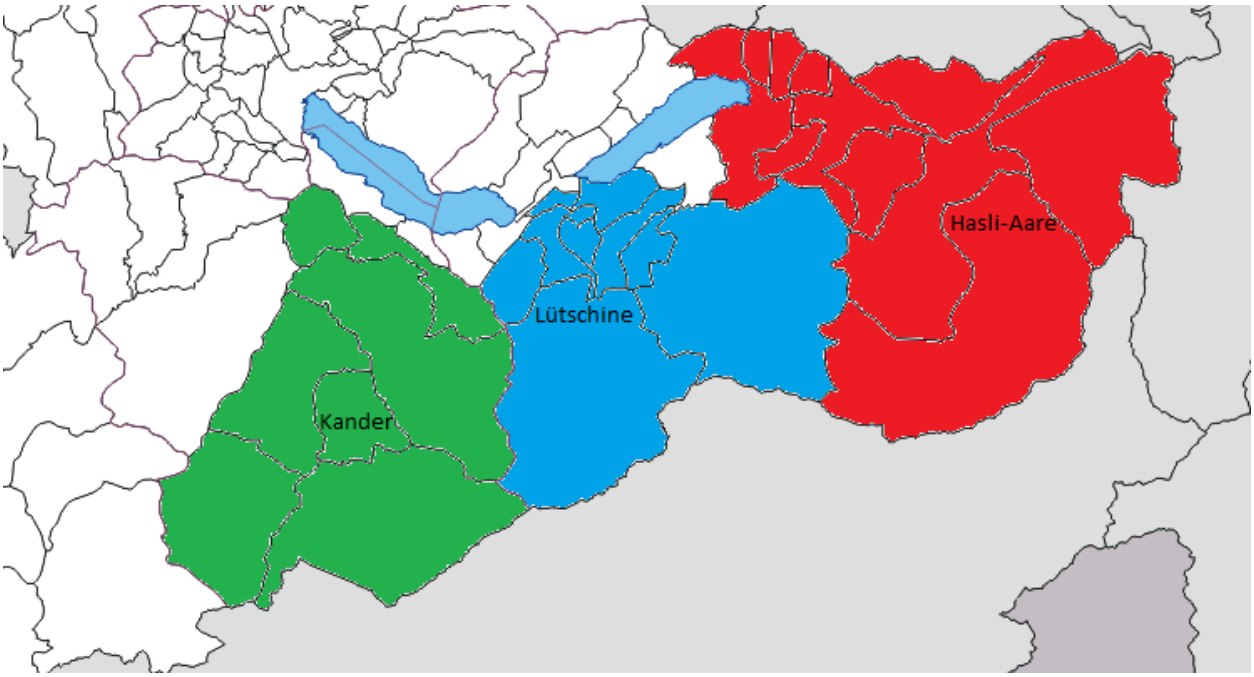

Figure 2: Map of the Three River Catchments within the Single Case Study (green: the Kander catchment, blue: the Lütschine catchment, red: the Hasli-Aare catchment, white: the canton of Bern, light grey: other cantons in Switzerland and dark grey: Italy)

The research question specifies that this research project focusses on flood resilience in mountainous areas. Three catchment areas within one mountainous region have been selected: the Kander catchment, the Lütschine catchment and the Hasli-Aare catchment (figure 2). All three of these river catchments are located in the Canton of Bern, which is known for its mountainous `Bernese Oberland` (Kimmerle et al., 2013). More information on the region and how this region is embedded in the Swiss federal democracy is given in chapter 4. The Bernese Oberland contains four river catchments that can be categorised as 'mountainous'. The Hasli- Aare, Lütschine and Kander catchments are significantly more mountainous than the lower Diemtigtal. The Diemtigtal does not contain any substantial glaciers nor permafrost, which limits the causes of the flood risks to less mountainous problems. On top of this, the Diemtigtal is less isolated. As the Diemtigtal is considerably different from the other three mountainous river catchments, it was excluded from the research, leaving three mountainous river catchments to be the area of investigation. The FRGA within these three river catchments forms the unit of investigation.

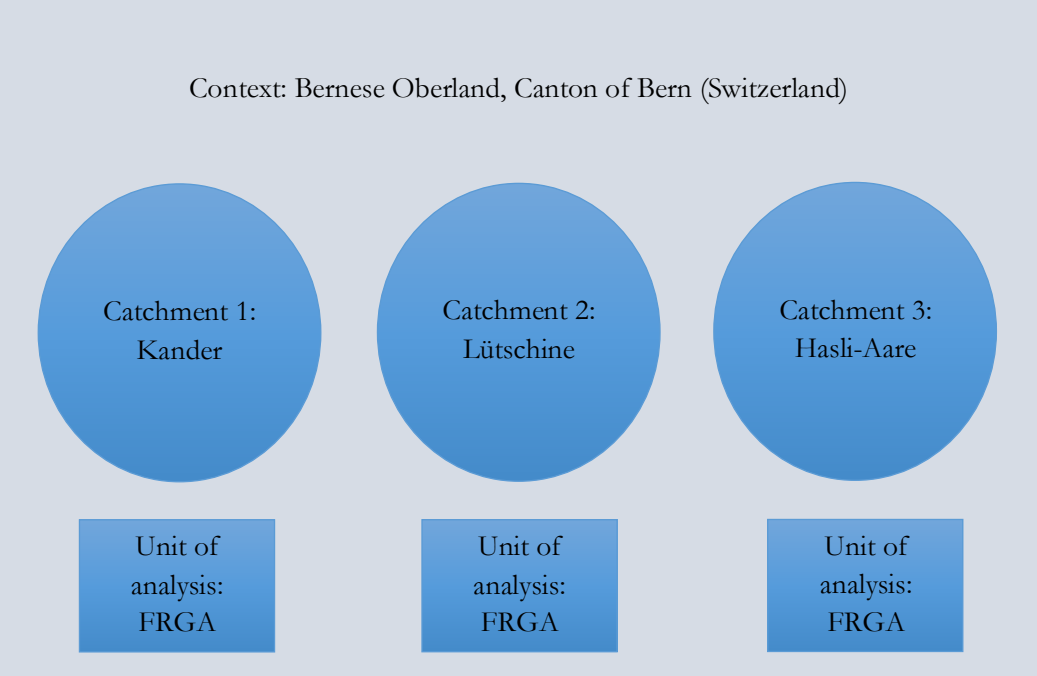

Figure 3: A visualisation of the case study context (Based on Yin, 1992)

The selected areas have encountered several floods in the recent past, severely in 2005 and more locally in 2011 (Raaflaub, 2011). In 2005 more than ten times the average amount of water found its way down the rivers, leading to extreme circumstances and to large damage to local housing and infrastructure (BAFU, 2008; BAFU, 2018).

All three case studies have similar characteristics. All three case studies are in a similar governmental and geographical context. The case studies are located in the country of Switzerland, assuring the national laws to be identical. All three case studies are located in the canton of Bern, making the cantonal laws equal as well. This means that the national nor the cantonal FRM policy differ between the cases, so the focus can exclusively be on the local FRGA. A single catchment area under study might be heavily influenced by a single actor or event, which is less likely with three catchment areas (Baxter & Jack, 2008).

Some differences between the river catchments exist (see Table 4). The Hasli-Aare is the less densely populated and the more isolated river catchment, compared to the other two. The (Hasli-)Aare is also the biggest river with the highest outflow. The number of municipalities is similar between the river catchments. The three catchment areas together are believed to form a good insight into flood resilience in the FRGA in mountainous areas.

Comparison of the Analysed Catchment Areas			
Characteristic	**Kander**	**Lütschine**	**Hasli-Aare**
Size of the catchment area	491 km^2	381 km^2	555 km^2
Number of Municipalities in the	7	10	8

Catchment Area (see Appendix 4)			
Number of Water Boards in the Catchment Area (see Appendix 4)	5	5	6
Population (see Appendix 4)	20.644	21.966	11.684
Percentage Glacier	5.1 %	13.5 %	15.5 %
Average Water Outflow of the Main River (2017)	18.6 m^3/s (Kander in Heustrich)	18.0 m^3/s (Lütschine in Wilderswil)	33.9 m^3/s (Aare in Meiringen)
Highest Measured Water Outflow of the Main River (River in Year)	273 m^3/s (Kander in 2005)	254 m^3/s (Lütschine in 2005)	444 m^3/s (Aare in 2005)

Table 4: Characteristics of the three catchment areas (BAFU, 2018)

3.5 Initiation of the Research

The start of a Master's thesis can be a complex endeavour. The field work of this Master's thesis was to take place in a foreign country, complexifying the initiation even more. For this reason, it was essential to start the research with exploratory talks. As the author was welcomed as a research scholar at the university of Bern, multiple exploratory talks have taken place there, with experts of this university. These were held in order to become familiar with the FRGA structure as well as with cultural, linguistical and political differences. Experts from the University of Bern that were consulted for the exploration of the local circumstances were dr. Karin Ingold, dr. Anik Glaus and dr. Laura Herzog. Dr. Ingold is the chair of the Policy Analysis and Environmental Governance research group and a native Swiss. Dr. Glaus majored in a flood risk management project, which included parts of the canton of Bern and dr. Glaus is a local. Talking with these two scientists was very insightful and helped gain a lot of in-depth information. Dr. Glaus' background in flood risk management policy in the area allowed for the understanding of different organisations and the passing on of important contacts. Dr. Herzog is a water management scholar in a related field, with a German background. The foreign background enabled her to provide the author with insights on the cultural peculiarities of the canton of Bern. On top of the exploratory talks, multiple books and documents were recommended and have been read for a complete understanding of flood risk management in the Bernese Oberland (e.g. Summermatter, 2012; Vischer, 2003 AG, NAGEF, 2013).

3.6 Method of Data Acquirement 1: Documents

Multiple methods can be used to acquire the final data for the analysis (Grix, 2002: p. 180). This research project is based on different qualitative methods to gather data. Firstly, the author of this Master's thesis has looked into the existing policy documents, and secondary literature to find out to what extent the different measures can be found in the policy documents. Secondly, the document analysis is supported by interviews with local flood risk management practitioners. These interviews can clarify the local implementation of the different measures. The analysis of the document combined with the analysis of the interviews allows the different dimensions to be evaluated in the case studies. Table 5 shows how these two main forms of data

gathering are combinedly analysed to form a complete analysis. The focus on the different dimensions of flood resilience, which are the basis of the research question, forms the rest of the structure of the research.

Outline of the Analysis						
Criteria	**Robustness**		**Adaptability**		**Transformability**	
First Criterion	Structural measures: document analysis (§5.1)	Structural measures: interview analysis (§5.2)	Renaturalisation: document analysis (§6.1)	Renaturalisation: interview analysis (§6.2)	Lessons learnt: document analysis (§7.1)	Lessons learnt: interview analysis (§7.2)
Second criterion	Spatial measures: document analysis (§5.3)	Spatial measures: interview analysis (§5.4)	Insurance: document analysis (§6.3)	Insurance: interview analysis (§6.4)	Future challenges: document analysis (§7.3)	Future challenges: interview analysis (§7.4)
Third criterion			Evacuation plans: document analysis (§6.5)	Evacuation plans: interview analysis (§6.6)	Experimentation: document analysis (§7.5)	Experimentation: interview analysis (§7.6)
Fourth criterion			Local protection: document analysis (§6.7)	Local protection: interview analysis (§6.8)		
Conclusion	Robustness conclusions (§8.1)		Adaptability conclusions (§8.2)		Transformability conclusions (§8.3)	

Table 5: Outline of the Analysis

The main policy documents that are used as data for the research are the `Gewässerrichtplans` of the different river catchments. A Gewässerrichtplan is an elaborate document on the current flood management projects that are currently being operated in the catchment areas (see §4.7). This is a rather new conceptualisation in which the problems of floods are not seen as a municipal responsibility but are addressed on a higher level. The Gewässerrichtplans are obligatory for every bigger river in Switzerland and are written by the Oberingenieurskreis (OIK (Chief Engineer District, see §4.4)). The Hasli-Aare and the Kander area already have a Gewässerrichtplan (GRP) (OIK I, 2013a; OIK I, 2013b). The Lütschine catchment does not have a GRP yet, which is an interesting matter for this study.

Next to the GRP documents, the document analysis looked at local reports, such as individual measures and reports from the local water boards. These were found through the interviews and through internet searches on local river measures. On top of all of this the reports the government (BAFU, www.bafu.ch) and the expert platform (PLANAT, www.planat.ch) have been used for background information. All of the documents have been coded and analysed using the data analysis tool ATLAS TI. The coding schemes were identical to the indicators (see 3.9). The main documents that have been used for the analysis are mentioned

in table 6. More information on narrow topics has been acquired through the internet and is mentioned individually in the analysis itself.

List of Analysed Documents				
Document	**Governmental level/ Catchment**	**Authority**	**Dimension(s) of Flood Resilience**	**Length** (pages)
Analysis 2005 Floods "Ereignisanalyse Hochwasser 2005"	Federal Government	BAFU (BAFU, 2008)	All, with a focus on Transformability	217
Scientific Report on the Effects of Climate Change on the FRGA "Starkniederschläge und Hochwasser"	Federal Government	BAFU (BAFU, 2016)	All, with a focus on Transformability	51
National document on Goals of Natural Hazard Management "Leben mit Naturgefahren"	Federal Government	BAFU (BAFU, 2011)	All	8
Document on the Responsibilities of the Canton and Municipalities "Achtung Naturgefahren"	Cantonal Government	Workgroup Natural Hazards of the Canton of Bern (AG NAGEF, 2013)	All	48
Gewässerrichtplan Kander	Kander	OIK I (OIK I, 2013b)	All	58
Local Project: Hochwasserschutz Engstlige	Kander	OIK I, Municipality of Frutigen (OIK I, 2015)	Robustness, Adaptability	83
Local Project: Hochwasserschutz Reichenbach	Kander	OIK I, Waterboard of Reichenbach (OIK I, 2018)	Robustness	58
Ecological Report Kander "Läbigs Kanderwasser"	Kander	OIK I (Amt für Landwirtschaft und Natur des Kantons Bern, 2007)	Adaptability	108
FRM Document Bödeli "Hochwasserschutz Bödeli Lütschine" (including overview document)	Lütschine	OIK 1, Waterboard Bödeli Süd (Bödeli Süd, 2019)	Robustness, Adaptability	25

Historic overview of flood risk management Lauterbrunnen "Hochwasserschutz und wasserbauliche Planung im Wandel der Zeit"	Lütschine	Municipality of Lauterbrunnen (Hitz, Amacher, Künzi & Schwab, 2014)	Robustness	11
Gewässerrichtplan Hasli-Aare	Hasli-Aare	OIK I (OIK I, 2013a)	All	154
Historic overview of flood risk management Innertkirchen "Hochwasser & Schwellenbauten Innertkirchen" (including current projects)	Hasli-Aare	Waterboard of Innertkirchen (Schwellenkorporation Innertkirchen, 2017)	Robustness, Transformability	27

Table 6: Analysed Document List

3.7 Method of Data Acquirement 2: Interviews

The second data collection method of this research project has been to hold semi-structured interviews (Bryman, 2016; p. 199). These interviews were conducted with the main actors in the formation of the FRGA (such as municipal experts and project leaders of the Gewässerrichtplans). The contact details that were provided by dr. Glaus combined with an exhaustive internet search resulted in a list of potential interviewees, with intimate knowledge of the flood risk management situation within the case study region. These interviewees were contacted, initially via e-mail, using a university of Bern mail-address. Most of the potential interviewees replied within a week with a possible date for the interview. Others were contacted again through e-mail or by phone, which resulted in the list of interviewees that follows below.

The semi-structured interviews were based on the analytical framework, but left room for additions from the interviewees to ensure the completeness of the acquired information. This follows the idiographic approach, in which the interviewees sketch a very detailed social context (Neuman, 2011). Adopting this approach allows this research "to describe specifics and highly detailed accounts of the particular social reality that is being studied (Wahyuni, 2012; p. 71)". The interviews are conducted with local experts from the responsible organisation in the OIK and Municipality. The interviewees have been interviewed in person within their own environment for visual aid. The in-person-interviews had several advantages over phone interviews. The most prominent advantage was the visual aspect. Interviewees were able to show their efforts in a direct manner (Bryman, 2013). Their expressions and questions were clearer by meeting face-to-face as well. This was very important given the already existing language barrier between a Dutch interviewer and Swiss-German interviewees. The level of English of the interviewees was not sufficient for the interviews, by the interviewees own reckoning. The interviews were therefore held in (Bärndütsch dialect) German and have been transcribed verbatim into English (See Appendices 2 & 3). For the interviews the author learned the language of the local people, as using a translator has multiple disadvantages. Using a translator does not allow the interviewer to respond directly to any remarks by the interviewees, nor does it allow the author to

understand and respond to any implied references within the spoken responses. "a translator is also engaged in the process of understanding and interpretation. Hence, translators working on a multilingual research project participate in the production of meaning, too (Fersch, 2013; p.90)." This quote shows that using a translator would make the information that is gathered through the interviews become secondary as it includes the interpretation of the translator. As the local people were unable to fluently communicate in English or Dutch and a translator would decrease the quality of the information, the author chose to hold the interviews in the local language. For readability and validation reasons, the interviews have been transcribed into English. The original recordings (in Bärndütsch) are available and can be accessed with consent of the author.

The interviews followed a set of questions that can be found in appendix 2. The interviews are structured along the three dimensions of flood resilience (robustness, adaptability and transformability), that have been extracted from the literature review. Each of these dimensions has a set of subdimensions or indicators which can be evaluated with qualitative information. Every interview started with a short introduction on the topic, an introduction of the interviewer and interviewee and a few practical questions. Then the interviews followed the order of the flood resilience dimensions that has been used throughout this research. The interviewees get to respond to the questions in their own way, following the idiographic approach (Neuman, 2011). Extra caution was put into this element as their interpretation is important in the interpretivist epistemology, as noted by Rubin and Rubin (2005). The interviewees have been asked if the interviews could be used for this research and could be recorded. They have agreed to the use of the information and have been able to verify the data, by e-mail.

For each river catchment an interview has been held with the responsible expert from the OIK (Hitz, 2018; Kimmerle, 2018; Fahrni & Stoffel, 201). They are the leading actors in each individual river catchment and know more than anyone else about the local FRGA (see §4.4 and §4.7). The flood risk management experts from the OIK are the experts on all different forms of policy in the area, as they are responsible for the GRP's, local measures and cooperation between different levels of governance. All the responsible experts have been contacted for an interview. In all three cases the local expert was eager to contribute to the research. The Hasli-Aare area is divided into a higher- and lower part so this area has two experts, who could be interviewed together. All four of these experts have been interviewed, creating complete data saturation on this level of governance (Fusch & Ness, 2015).

Interviewee List			
Organisation	**Interviewee**	**Governmental level**	**Catchment area**
Oberingenieurskreis I	Mr. Kimmerle	Cantonal	Kander
Oberingenieurskreis I	Mr. Hitz	Cantonal	Lütschine
Oberingenieurskreis I & II	Mr. Stoffel & Mr. Fahrni	Cantonal	Hasli-Aare
Tiefbauamt Frutigen	Mr. Birscher	Municipal	Kander
Schwellenkorporation Kandersteg	Mr. Weibel	Municipal	Kander
Schwellenkorporation Bödeli Süd	Mr. Matthias	Municipal	Lütschine
Schwellenkorporation Lütschental	Mr. Teuscher	Municipal	Lütschine

Schwellenkorporation Lauterbrunnen	Mr. Schai	Municipal	Lütschine
Schwellenkorporation Innertkirchen	Mr. Banholzer	Municipal	Hasli-Aare

Table 7: Interviewee list

The main governmental responsibility for the execution of FRM policy in Switzerland lies with its lowest bureaucratic level: municipalities (see §4.5). The municipality can choose to take this responsibility itself or to give it away to a smaller organisation that focusses solely on FRM. Most municipalities in the river catchments under study, have a separate organisation to deal with the flood risk in the area. These so-called 'Schwellenkorporationen' (water boards) are led by a group of local flood risk management experts (see §4.6). If the municipality does not have a separate organisation to deal with the flood risk, they have to manage it themselves. The responsible policy makers within the municipality, either from the municipality itself or from the water board, know most about the impact of the FRM policy on the local inhabitants and they are qualified to explain the spatial planning decisions in the region on a very local scale. Furthermore, they are likely to know most about the communication with the local people and the extent to which local future challenges are taken into account. The information from the local water boards in combination with the OIK and the documents on the local measures and the 'Gewässerrichtplan' have been able to create an in-depth understanding of the FRGA.

A total of 25 municipalities can be found within the area. Some of these work together, forming a bigger waterboard. The biggest example of this is the 'Schwellenkorporation Bödeli Süd'. Several municipalities have no water board, because the past has not shown problems with flooding. The municipality of Aeschi for example does not have many problems with flooding, as it is located on a hillside. Such municipalities cannot attribute much to the goal of this research and have therefore not been contacted for an interview. On top of this a few municipalities, such as Adelboden, are not a part of the 'Gewässerrichtplan' and have therefore been excluded (for a complete explanation of its exclusion see §4.5). A total of 11 municipalities/water boards have been contacted, to make an appointment for an interview in the municipality itself. Three of which did not respond to any contacting. Two municipalities responded, forwarding the research to a different municipality, for time-management reasons.

A total of six responsible organisations have responded to the invitations. The waterboards of Kandersteg, Bödeli Süd, Lütschental, Lauterbrunnen and Innertkirchen and the municipality of Frutigen have been interviewed for this research. This allows for a balanced representation of the municipalities. A total of 11 municipalities, out of the total of 25 municipalities have been covered by the interviews (see Appendix 4). Different sizes of water boards are included, as Frutigen and Bödeli Süd are among the biggest organisations, representing over 6000 inhabitants (see Appendix 4). Kandersteg (3370) and Lauterbrunnen (2406) are average sized municipalities. Innertkirchen (1087) is among the smaller municipalities and Lütschental (227) is a very small community.

The municipalities that have been interviewed all have a history of floods. The 2005 flood has hit all interviewed municipalities and some very heavily (i.e. Lütschental). On top of this some municipalities have suffered damage from the 2011 floods.

Two municipalities/water boards, the Schwellenkorporation Bödeli Süd and the municipality of Frutigen, form special cases. The Bödeli Süd waterboard forms a waterboard across multiple municipalities, forming a

cooperation within one catchment area, but not including the entire catchment area. This is a special case as this does not occur in other parts of the case study area. The cooperation within this organisation, as well as its communication with other similar organisations within the same catchment form a special case. Therefore, the interview with the leader of Schwellenkorporation Bödeli Süd has had extra focus on the local situation and cooperation. The water boards closest to this cooperation have also been interviewed (Lauterbrunnen and Lütschental).

The second special case is that of the municipality of Frutigen, which is the only municipality which is significantly exposed to flooding but does not have a waterboard. Their situation gives extra information about the execution of the decision-making, as the municipality needs to divide its attention, instead of being solely dedicated to FRM. This difference has proven to be strikingly decisive. Sadly, there is only one such municipality in the case study area. To gain more insights in this situation, the experts from the OIK have also been asked for their insight into this situation.

Including the special cases, an average of two interviews per catchment area have been held with the responsible municipal policy-makers. Conducting two interviews ensures that the information given by the decision-makers is more complete and less affected by personal preferences, even though it cannot be considered an extensive research population. The most important grounds for the limited number of interviews the limited number of experts in the area, and the focus on depth of analysis in spite of quantity of interviewees. The consequential limited validity has been considered by the author and is further considered in the discussion.

All of the responsible managers of the river catchments from the OIK have been interviewed, creating a complete representation of their work. The only large municipality without a water board has been interviewed, which forms a special case. Five leaders of the local water boards have been interviewed, spread over the three river catchments. One of these leaders is the leading FRM executioner of over half the Lütschine river catchment. This number of interviews, in combination with the thorough analysis of the FRM documents has created the opportunity to analyse every remark about the FRGA and this thesis builds a complete in-depth analysis and evaluation of the entire FRGA. Assessing the local FRGA in this manner has allowed a complete evaluation of the different dimensions of flood resilience on a local level in the Bernese Oberland.

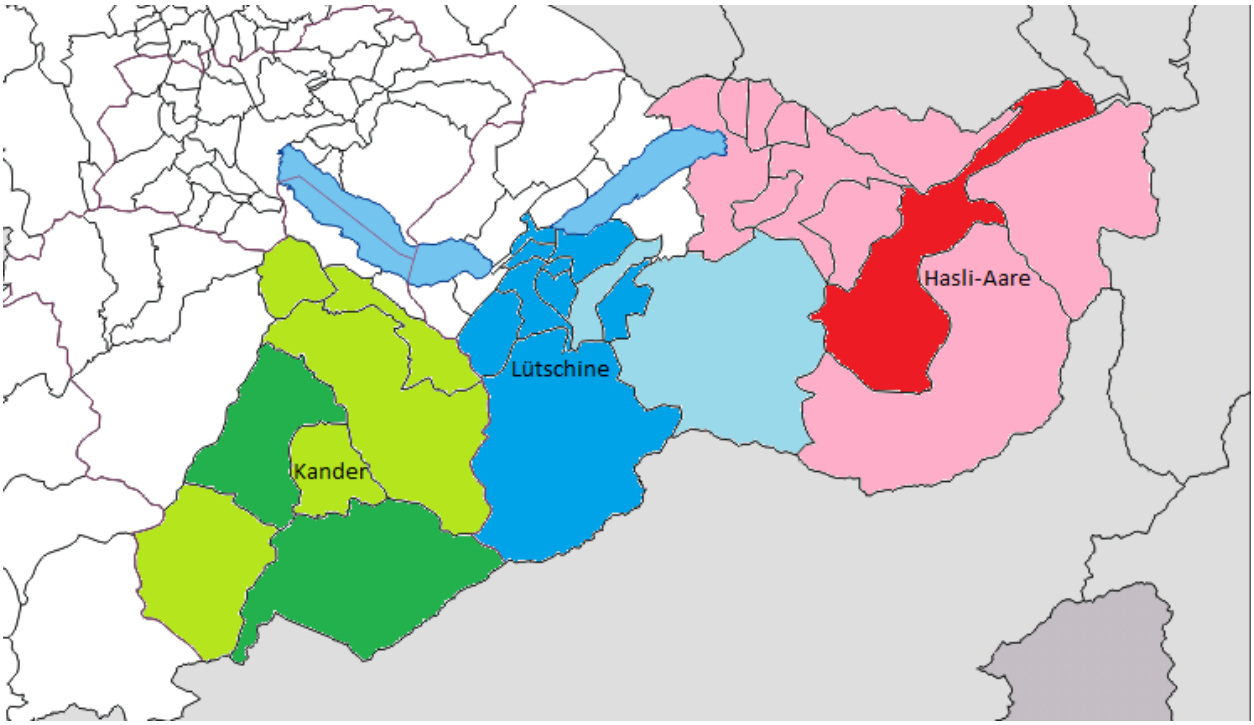

Figure 4: The Municipalities of which the responsible authority has been interviewed (darkened), (green: the Kander catchment, blue: the Lütschine catchment, red: the Hasli-Aare catchment, white: the canton of Bern, light grey: other cantons in Switzerland and dark grey: Italy)

3.8 Data Triangulation

The exploratory talks with scientists from the University of Bern (See §3.5) brought forth an initial silhouette of what the data would look like. This silhouette has been solidified by a combination of the data from the documents and the interviews. These interviews all took place in the research area, giving the interviewer the opportunity to observe the local rivers and the measures that were taken to prevent those rivers from damaging the local communities. It also allowed the researcher to take photographs of certain measures to visually aid this Master's thesis: i.e. through site visits. "[S]ite visits are used for different purposes by different professionals, but the general goals are to get a sense for the physical site, find patterns, and discover and record new insights about the physical location and its characteristics (White & Feiner, 2009; p. 1117)". In the case of this research, the site visits were used to verify the status of the local implementation of the measures and to visually document the (status of the) measures. This verification of the collection of the data, stemming from the other two forms of data acquirement can be seen as data triangulation (Wayhuni, 2012). Data triangulation is an important tool to increase the data saturation and thereby the validity of the research (Ness, 2015).

3.9 Operationalisation

The three different dimensions of flood resilience are broad and can be considered abstract terms. Before they can be found in the documents and the interviews, they therefore have to be operationalised. By operationalising the dimensions, the different components of the data can structurally be analysed to ensure a clear overview of the insights are to be found.

The operationalisation consists of four different steps. Firstly the four dimensions of the PAA (see §2.7) need to be located in the available data. These dimensions define which aspects of the data are relevant and where this relevant information can be found. The second step is to formulate criteria that indicate the extent to which the different dimensions of flood resilience are supported by the FRGA. These criteria are extracted from the literature review. The next step is the identification of indicators of the criteria, to ensure that the available data can be analysed adequately, and the interviewees can be asked the proper questions. Finally, these indicators need to be made evaluable by distinguishing between different levels of goal achievement.

Locating the Four Dimensions of the PAA

Dimensions of the PAA and their Allocation in this Research		
Dimension of the PAA	**Definition (Kaufmann, 2017; p. 83)**	**Position in this Research**
Discourse	Ideas, principles and objectives within the FRGA	Analysis of both the interviews and the documents
Rules	Formal and informal rules, regulations and routines	Analysis of documents and to some extent analysis of the interviews
Actors	Responsibilities, preferences and interests of the involved actors	Analysis of the interviews and to some extent analysis of the documents
Power/Resources	Use of finance, expertise, network and legal position	Analysis of both the interviews and the documents

Table 8: PAA Dimensions

Table shows the definitions of the different dimensions of the PAA as described in §2.7 (Kaufmann, 2017). The dimensions form the main focus of the analysis that forms the main body of this research (chapter 5, 6 and 7). The discourse, including the ideas, principles and objectives of the local stakeholders on the local FRGA has been analysed through a combination of the documents and the interviews. In the documents, certain ideas about the discursive trends in the local FRGA are visible, these are then confirmed and explained by the local interviewees. The rules dimension has two sides, a formal part including laws and regulations and an informal part including local interpretations and handlings. The first can mainly be identified in the analysis of the documents, whereas the latter is also prominently visible in the understanding of the local interviewees. The functioning of the actor dimension of the PAA can to some extent be derived from the documents but is mainly subjective to their own understanding which is identified in the analysis of the interviews. The power/resource dimension of the PAA focusses on the allocation of different forms of resources. This is a very prominent part of the analysis and is derived from a lot of information from both the interview- and the document analysis. Together these four dimensions of the PAA form the policy arrangement that is the subject of this research. Within these different dimensions, which are intertwined, this research investigates if the current policy arrangement (the local FRGA), supports or constrains a holistically flood resilient flood risk management policy.

Formulating Criteria of Flood Resilience

As intensively discussed in the previous chapters, three dimensions of flood resilience have been derived from the literature. The three dimensions are robustness, adaptability and transformability. These three dimensions are now to be divided into evaluable criteria. Two criteria for robustness have been selected: structural measures and spatial measures. Four criteria have been selected to evaluate adaptability:

renaturalisation, insurance, evacuation plans and local protection. Finally, three criteria have been found to evaluate the transformability of the FRGA: lessons learnt, future challenges and experimentation. Together these nine criteria form a complete evaluation of the degree of flood resilience of the FRGA in the Bernese Oberland. Table 9 shows the nine evaluation criteria with the corresponding literature references and interview questions. See Appendix 1 for an overview of how the criteria have been derived from the literature.

Evaluation Criteria in the Theory and in the Interview Outline (see appendices 1 & 2)			
Criteria	**Dimension of Flood Resilience (Restemeyer, Woltjer & van den Brink, 2015)**	**Respective Aspect of Flood Resilience According to Hegger et al. (see appendix 1) (2016)**	**Interview Question (See Appendix 2)**
1.) Structural Measures	Robustness	Flood Defence	3 (5 and 6)
2.) Spatial measures	Robustness	Flood Prevention	4 (5 and 6)
3.) Renaturalisation	Adaptability	Flood Mitigation	7 (10 and 11)
4.) Insurance	Adaptability	Flood Recovery	7 (10 and 11)
5.) Evacuation Plans	Adaptability	Flood Preparation	7 (10 and 11)
6.) Local Protection	Adaptability	Flood Mitigation	9 (10 and 11)
7.) Lessons Learnt	Transformability	Flood Preparation	2
8.) Future Challenges	Transformability	-	12, 13 and 14 (16)
9.) Experimentation	Transformability	-	15 (16)

Table 9: Evaluation Criteria in Theory and Interviews

Formulating Indicators for the Criteria of Flood Resilience

The criteria that have been derived from the literature review now have to be measurable so they can be evaluated. The first step to make them evaluable is to add an indicator to every criterion. Table 10 shows how the indicators that show the criteria, as well as an example to make the indicators more understandable.

Examples and Indicators of the Evaluation Criteria		
Criteria	**Practical Example**	**Indicator of the criterion**
1. Structural Measures (Robustness)	Structural measures such as dams, dikes, retaining areas and higher bridges, that lower the probability of flooding.	Heightening of the flood resistance (HQ) through structural measures.
2. Spatial measures (Robustness)	Spatial measures that lower the potential damage of flooding by transferring economic activity to less vulnerable locations	Lowering of the value of properties in (extremely) vulnerable areas.

3. Renaturalisation (Adaptability)	Naturalisation measures that enhance the natural resilience of the river environment	Measures in place or planning to promote the natural environment around rivers.
4. Insurance (Adaptability)	Financial security is present that allows people to return to normal after a flood has occurred.	The right financial means have been set aside before a flood happens.
5. Evacuation Plans (Adaptability)	Evacuation plans are in place and functional to ensure the safety of people in case of a flood.	Evacuation plans are in place and known to the local people.
6. Local Protection (Adaptability)	Local measures are stimulated that protect individual valuable infrastructure and buildings.	Vulnerable local properties of value are protected individually.
7. Lessons Learnt (Transformability)	The causes of floods in the past have been evaluated and have shown insights for flood resilience in the future.	Floods that occurred have been evaluated and steps have been taken to ensure they would not have the same impact again.
8. Future Challenges (Transformability)	The FRM policy does not solely focus on problems as they have occurred but looks ahead to what problems might arise or grow.	Potential problems and uncertainties have been evaluated and taken into account in the decision-making.
9. Experimentation (transformability)	New solutions that can lower the flood risk have been considered or executed.	Innovative solutions have been considered in the decision-making.

Table 10: List of Indicators

Appendix 1 shows how the criteria have been derived from the theory. Some of the criteria give insights into multiple dimensions of flood resilience. All aspects of flood resilience have been covered, although the fostering of societal change is abstract and is stretched over multiple indicators. Societal change is stimulated by the creation of awareness of the flood risk. Societal change is therefore not limited to the three indicators of transformability, but can also be identified in several adaptability measures, such as the promotion of local protection measures, evacuation plans and insurance.

The indicators that have been mentioned and clarified with a practical example need to be specified to distinguish between different levels of goal achievement. The indicators are mentioned below to explain their exact functioning and are given specific levels of goal achievement in the next section.

Robustness 1: Structural Measures

The first indicator of robustness is the flood protection in the traditional sense. As illustrated in Appendix 1, Alexander et al. consider structural measures a part of flood defence (2016). For centuries societies have tried to prevent floods from occurring by building dams and other structural measures. These measures help to safeguard society from floods. The higher and stronger the dams are, the higher levels of water they can overcome. The level of safety by these measures is put into numbers using 'HQ standards' (H stands for 'high' and Q is a mathematical letter denoting 'Quantity'). The HQ standards show the robustness of the current combination of measures for a certain area. If an area is HQ30 that means the area is safe for a flood event that is projected to happen once every 30 years. The higher the number is, the less vulnerable the area is to floods. The HQ is a very important standard to see how well prepared areas are to prevent floods. Some

areas are naturally more prone to flooding giving them a lower HQ score. This has to be taken into account in the analysis. Therefore, this criterion does not only look at the mere scores on HQ, but also at the measures that have been taken to heighten these scores.

Robustness 2: Spatial Measures

The second indicator that can measure the robustness of the FRGA is prevention through the abandonment of flood prone areas. As illustrated in Appendix 1, Alexander et al. consider spatial measures a part of flood risk prevention (2016). The first step to achieve a more robust society through spatial measures is by finding out which areas are vulnerable to floods. Once this is known, action can be taken to either make this area more robust using structural measures (first indicator), or by leaving the most vulnerable areas altogether. This second option is called 'spatial measures'. The (economic) value of the properties that are still in the most exposed areas shows how much focus on spatial measures has been performed. Together with the Structural measures, these two indicators indicate the focus on the dimension of robustness of the local FRGA in the Bernese Oberland.

Adaptability 1: Renaturalisation

Adaptability looks at how the local FRGA lowers the potential damage of a flood event. As illustrated in Appendix 1, Alexander et al. consider renaturalisation a part of flood mitigation. Renaturalisation is a way to lower the (economic) damage of a potential flood. By giving nature more space and by letting natural processes develop, society can lower the impact of a flood to society. A natural solution to the flood problem is often the cheapest and the aesthetically most pleasing solution. Many different measures can be taken to renaturalise an area. Examples include giving the river more space, leaving materials and trees in the river bed and lowering artificial waterfalls. These measures need to be given priority, not only to lower the potential damage of a flood to society, but also to help the natural ecosystem survive a flood event. A simple assessment of the number and extent of projects that benefit nature shows the focus on renaturalisation within the local FRGA.

Adaptability 2: Insurance

A flood can have long lasting consequences if the victims cannot rebuild their properties. The availability of insurances ensures that the local community is able to rebuild itself, so a flood has as little impact as possible. As illustrated in Appendix 1, Alexander et al. consider insurance a part of flood recovery, although it can also help foster societal change through the creation of awareness (2016). The availability of insurances has been checked by looking at the handling of the damage of major floods in the past and the changes to this policy.

Adaptability 3: Evacuation Plans

The third manner to lower the impact of flood events is through evacuation plans. As illustrated in Appendix 1, Alexander et al. consider evacuation plans a part of flood preparation although it can also help foster societal change through the creation of awareness (2016). Through evacuation plans, lives can be saved during a flood event. Good evacuation plans require a lot of different aspects: both the local people and the emergency services need to know what to do, and people need to be aware of the risks. Warning systems are an important aspect of the evacuation plans. A combination of several segments of good evacuation plans has been used to evaluate this criterion. Firstly, evacuation plans need to exist. These then have to be known by the evacuators as well as the evacuees. All in all, evacuation plans are an important aspect of the adaptability to floods of the FRGA.

Adaptability 4: Local protection

The last of the four indicators that form the evaluation of the adaptability of the FRGA is called 'local protection'. As illustrated in Appendix 1, Alexander et al. consider local protection a part of flood mitigation, although it can also help foster societal change through the creation of awareness (2016). Valuable properties in a vulnerable area can be protected locally to ensure its safety even when the rest of the area is flooded. The local protection measures can take different shapes, from a heightening of a building to a small dam or gulley. The existence of such measures can make a big difference and forms the last criterion to evaluate the adaptability of the FRGA in the Bernese Oberland.

Transformability 1: Lessons Learnt

Transformability shows to what extent an area is prepared for future challenges. As the future is uncertain, one way to look at how prepared an area is for future challenges, is to consider the past. As illustrated in Appendix 1, Alexander et al. mention lessons learnt as a way to learn from past events, although their focus on this indicator is limited (2016). Future flood events may be even bigger than the biggest flood events in history. To look at the lessons learned from the biggest flood events in the past is therefore a prerequisite to be prepared for the future. This criterion therefore evaluates to what extent historical flood events, such as the 2005 floods, have helped the area prepare for new challenges. The evaluation focuses on changes that have occurred thanks to knowledge from past floods and on whether an event like the ones in the past would still have the same impact in the future.

Transformability 2: Future Challenges

The past will never repeat itself in exactly the same manner. Considering future challenges is a way to deal with deep uncertainty (Buurman & Babovic, 2017). As illustrated in Appendix 1, Alexander et al. also see the dealing with future challenges as society's adaptive capacity (2016). Therefore future challenges that cause different circumstances need to be taken into account. One of the most important factors that can cause challenging circumstances in the future is climate change. Climate change can cause many changes that might cause floods. The melting of permafrost and glaciers could cause more rock and other materials to come down. This can cause natural dams which in turn cause floods. The changing climate could cause more peak rains and droughts. These challenges and their consequences have to be considered in the decision-making.

Transformability 3: Innovation and Experimentation

New challenges also ask for new measures. Therefore experimentation and innovative solutions have to be encouraged to make sure new challenges can be countered effectively. Alexander, Priest and Mees see the capacity to adapt as the need to learn, experiment, innovate and deal with the uncertainties of the future (2016). Innovation thusly ensures progress in the policy field. This criterion focusses on if new ideas are being considered, when a project is being planned.

Defining Levels of Goal Achievement for the Indicators of the Criteria of Flood Resilience

The final step to make the criteria evaluable is to clarify the different levels of goal achievement of the indicators. Table 11 shows the different levels of goal achievement for all nine indicators. The indicators are not scored on a permanent scale, but on a slanted scale to show that policy implementation is a process. Therefore an insufficient score does not mean all efforts have been in vain. Advancing means the policy is on its way to being satisfactory. Likewise, good means that the aspect of flood resilience has sufficiently been taken into account in the current FRGA, but the standards can change, which could lead to an insufficiency

in the future. Not all indicators can be evaluated completely. Certain data do not give satisfactory answers to some of the indicators for various reasons, such as lacking answers of interviewees, interview errors and focussed (and therefore narrow) documents.

Different Levels of Goal Achievement for the Evaluation Criteria			
Criteria	**Insufficient**	**Advancing**	**Good**
1.) Structural Measures (Robustness)	Structural measures do not show any heightening of the HQ in the area and are lower than the governmental requirements.	Structural measures have been taken to to heighten the HQ of the area, although the HQ is still below the safety standards.	Structural measures have been taken to reach or surpass the safety standards.
2.) Spatial measures (Robustness)	Spatial measures have not been taken to lower the potential damage within vulnerable zones.	Spatial measures have been taken to lower the potential damage within vulnerable zones, but some exposed objects still exist.	Vulnerable zones have been identified and cleared of all valuable properties.
3.) Renaturalisation (Adaptability)	The rivers are completely canalised with no regard to its ecosystem.	The ecosystem of the river has been taken into account and steps have been taken to its betterment.	The ecosystem of the river has been restored to give the river and all its life more space.
4.) Insurance (Adaptability)	No financial means are available to undo the damage of a flood.	Financial means are available to undo the damage of a flood, but the availability is unclear or requires a lengthy process.	Financial means to undo the damage of a flood are available to all victims of flooding.
5.) Evacuation Plans (Adaptability)	No evacuation plans are available.	Some evacuation plans are available but the execution is not known to the people involved.	Evacuation plans are available and well distributed and practiced.
6.) Local Protection (Adaptability)	No local protection measures have been placed.	Some local protection has been implemented, but not structurally.	Valuable properties in vulnerable areas are well protected individually.
7.) Lessons Learnt (Transformability)	The floods have not been evaluated and similar circumstances	The floods have been evaluated and some action has been taken	The floods have intensively been studied and lessons have been drawn to

	would result in similar or worse damage.	to lower the impact of a similar event.	prevent flooding in similar circumstances.
8.) Future Challenges (Transformability)	The local decision-makers are unaware of potential future challenges.	The local decision-makers are aware of the existence of potential future challenges, but little action is taken to fight these challenges.	The local decision-makers are aware of the existence of potential future challenges and have taken action to prevent potential problems.
9.) Experimentation (Transformability)	There is no room for innovation and experimentation in the FRGA.	Innovation and experimentation can be considered in the decision-making process.	Innovation and experimentation are actively stimulated to find new and better solutions to local problems.

Table 11: Levels of Goal Achievement for the Criteria

The operationalisation of the data results in nine distinct criteria that form one coherent evaluation of the local FRGA in the Bernese Oberland. This use of a set of criteria to form an analysis is called the Multicriteria approach (MCA) (Awashti, Chauhan & Goyal, 2010). MCA is a broad method to assess policy implementation. As the name suggests, the MCA can use multiple criteria to integrally assess the implementation of a certain policy. This method has been used in different settings and has proven to be a useful method to evaluate policy implementation. The MCA is used both in policy selection research (e.g. Cavallaro & Ciraolo, 2005) and in policy evaluation research (e.g. Awashti, Chauhan & Goyal, 2010).

The data that is collected through the document analysis and the semi-structured interviews is used to evaluate the different dimensions of flood resilience of the FRGA in the three case studies in the Bernese Oberland, using the criteria and indicators that have previously been described. The results have two important implications. First of all, the end results on the specific aspect of flood resilience show where policy makers should focus on most in new policies. It shows where the local FRGA is not yet sufficiently flood resilient. Secondly, the results on the specific catchment policies are useful for the local policy makers to see how they score relative to their neighbouring catchment areas, in order for them to be able to learn from other local experts.

Chapter 4: Context of the Study

This thesis is written for two universities, the Radboud University Nijmegen in the Netherlands and the University of Bern in Switzerland. This chapter is intended to improve the readability of the thesis for readers with a non-Swiss background. It forms an introductory chapter to explain the context of the analysis that follows. The chapter starts with a short introduction on governance on a federal state level followed by an explanation of the different levels of governance in Switzerland (cantonal, regional and municipal) and its most important stakeholders (OIK and waterboards) in FRM. Finally, this chapter explains what the GRP documents are and what they mean to achieve.

Table 12 gives an overview of the different sections of this chapter. The government on each level decides what rules need to be implemented, which are then carried out by the organisation that is responsible for FRM on each respective level, with the use of important FRM documents. By explaining these aspects of the FRGA, chapter four gives an outline of the different aspects of the PAA, focussing on the actor and rules dimensions.

Main Actors/Documents in the Implementation of FRM Policy in the Bernese Oberland			
Governmental Level	**Government**	**FRM Organisation**	**Important Documents**
National (Switzerland, §4.1)	National Parliament	BAFU	Leben mit Naturgefahren (BAFU, 2011)
Cantonal (Canton of Bern, §4.2)	Grosser Rat	AG NAGEF/ OIK	Achtung Naturgefahren! (AG NAGEF, 2013) & Baugesetz 1985 (BauG., 1985)
Regional (Bernese Oberland, §4.3, §4.4 & §4.7)	-	OIK I	GRPs (OIK I, 2013a; OIK I, 2013b)
Local (§4.5 & §4.6)	Municipality	Tiefbauamt/ Schwellenkorporation	Local projects (e.g. OIK I, 2015; OIK I, 2018)

Table 12: Different Levels of Government

4.1 Switzerland

Switzerland is a country in the centre of Europe with about 8.500.000 inhabitants (BFS, 2019). The GDP per capita is $64,649, which is the ninth highest in the world. Geographically, about half the country, the southern half, is covered with high mountains: the Alps. In the north-west the Jura mountains are located, whereas most of the middle of the country is more habitable, covered with smaller hills.

Politically, the country is considered very stable (Ladner, 2001). It is a (semi-)direct democracy, where people get to vote on a lot of subjects using referenda, by which the people can overrule governmental decisions (Cormon, 2014). The legislative branch of the national government is divided up into two houses of parliament, the Council of States and the National Council. The executive branch consists of seven political leaders, of which the president and the vice-president are the official leaders, but they maintain a more

symbolic function. Next to their system of direct democracy, the Swiss are very proud of their federal system, decentralising many decisions to a cantonal level or even municipal level.

The main political decisions on flood risk management that impact the decision-making process in the Bernese Oberland are not taken on a federal level. Some organisations and documents are important, however. The BAFU, Bundesamt für Umwelt (Federal Office for the Environment) for example impacts the FRGA, as they give out strategies for local FRM practitioners to carry out, such as the document 'Leben mit Naturgefahren' (BAFU, 2011; BAFU, 2019). They are the centre of expertise, centralising all information of the different parts of the country. In doing so, they control the warning system (together with the Bundesamt für Bevolkeringsschütz (BABS, 2019)), give out update reports and monitor the local functioning of different actors and the state of the water. Political decisions on water management made on a federal level need to be implemented in cantonal law, indirectly impacting the local decision-making process.

4.2 Canton of Bern

The case study region, the Bernese Oberland is located completely within the Canton of Bern. The Canton of Bern is the second-largest of the 26 cantons of Switzerland. It contains the cities of Bern, Thun and Biel and a lot of surface to the north and east. It stretches from the northern border of Switzerland to the lakes in the west, to well within the alps in the south and to Luzern in the east. The language spoken in most of the Canton is a local dialect of German called 'Bärndütsch', but in some of the western parts French is the main language. Politically, Bern is the capital of the Canton of Bern. This is where the cantonal parliament (Grosser Rat) is housed.

Many political decisions that are important for flood risk management practitioners in the Bernese Oberland are taken on the cantonal level. The most important organisation on this level for flood risk management practitioners is the OIK (see §4.4). The OIK assists the local organisations. Next to the OIK, the cantonal government has a work group that is occupied with natural hazards. This agency has produced a guide on how to deal with natural hazards called 'Achtung Naturgefahren!' (AG NAGEF, 2013). Other agencies and documents on this level also determine the options of the local flood risk practitioners. The building laws for example, are important because they decide where buildings are allowed (BauG, 1985). The Gefahrenkarten (danger maps) (see §5.3 and §5.4), which form the basis of different flood risk management tools, are also made on a cantonal level (Geoportal des Kantons Bern, 2019).

4.3 Bernese Oberland

This case-study on flood risk management in Swiss mountainous areas is located in the Bernese Oberland (see §3.3). This is the Alpine region in the south of the canton of Bern. It consists of four administrative districts: Frutigen-Niedersimmental, Interlaken-Oberhasli, Obersimmental-Saanen and Thun. Only the first two districts (Frutigen-Niedersimmental and Interlaken-Oberhasli) are located in the high alps and are therefore the research subjects of this Master's thesis. The catchment area of the river Kander is located in the administrative district of Frutigen-Niedersimmental, whereas the catchments of the Lütschine and the Hasli-Aare rivers are located in the administrative district of Interlaken-Oberhasli. The Bernese Oberland does not have its own governmental authorities as it is part of the canton of Bern.

The river catchments that form the case study of this research are located in the higher parts of the Bernese Oberland. Together the three catchment areas are the home to just over 50.000 people. The tallest peak in the area is the Finsteraarhorn (4,274 m). Multiple large glaciers are to be found in the case studies. The Kanderfirn (Kander Catchment) the Tschingelfirn and the Grindelwaldgletscher (Lütschine catchment) and the Gauligletscher and the Aargletscher (Hasli-Aare catchment) are among the biggest glaciers of the Alps. These arctic environments are UNESCO protected, because of their natural beauty (Haslital Tourism, 2019). The river catchments are named after the main rivers that form the catchments. The Kander catchment also contains the Engstligen and Chiene rivers and many smaller rivers. The Lütschine catchment also contains both the Schwarze- and the Weisse Lütschine and many smaller rivers. The Hasli-Aare catchment contains the Gadmerwasser and the Urbachwasser as well as the Aare itself and many smaller rivers. All three of the catchments have similar characteristics, as they all contain many small fast-flowing rivers that are currently to some extent being fed by glaciers.

4.4 Oberingenieurskreis

The Bernese Oberland does not have its own government, but it does have a separate part of the Oberingenieurskreis (OIK) (BVE, 2019). The OIK is a governmental organisation that is responsible for multiple parts of the management of infrastructure in the canton of Bern. They are a part of the Tiefbauamt (engineering office) of the canton of Bern. The OIK is divided over different parts of the canton of Bern, making the OIK I responsible for the entire Bernese Oberland. Within OIK I, different parts of the organisation are responsible for different parts of infrastructure. There is a general office, an office for the maintenance and inspection of cantonal and municipal roads and an office for flood risk management. The latter is one of the most important stakeholders of this research. This special agency within the OIK that specialises in FRM is engaged in every project that has to do with FRM in the Bernese Oberland. Being engaged in every project means they are available to the local people of water boards and municipalities for advice on technical issues as well as contacts in the world of water engineering.

The FRM part of OIK I is divided up into different areas which, uncoincidentally are similar to the catchment areas that have been described in the case study selection (§3.3). The organisation is led by Mr. Stoffel, who is also responsible for the catchment area of the Hasli-Aare river (BVE, 2019). As the Aare river is one of Switzerlands longest rivers, he is accompanied by Mr. Fahrni of OIK II (Bern Middle lands). Mr. Hitz is responsible for the Lütschine area and Mr. Kimmerle is responsible for the Kander area. All four of these important stakeholders have been interviewed for a better understanding of their work and their impact on the local FRGA (see appendix 3).

4.5 Municipalities

The previously described part of OIK I advises the local municipalities on the subject of FRM (BVE, 2019). That is necessary as the municipalities have a lot of responsibility and sometimes limited expertise on this subject. Local projects are therefore often carried out in cooperation with the OIK (e.g. project Engslige (OIK I, 2015) and project Reichenbach (OIK I, 2018)) The municipalities have the responsibility to execute all of the cantonal laws and strategies that have been decided upon. Their responsibility gives them the opportunity to execute these laws and plans in the way they deem fit. Within the municipality there is a municipal 'Tiefbauamt' (engineering office), similar to the OIK on the cantonal level. This Tiefbauamt is

responsible for the entire municipal infrastructure, with optional advice from the cantonal Tiefbauamt. The municipalities have the real executive responsibility of flood risk management. They often outsource this responsibility to the water boards (§4.6) Within their own area, the municipal representatives, with the consent of the local people get to plan all the flood risk projects. They have to work together with other municipalities, however. How this works is explained in §4.7. Appendix 4 shows the population size and the respective water boards of all municipalities that are within the case study.

4.6 Water boards

As the municipal Tiefbauamt has the very broad task of governing 'the municipal infrastructure', they often outsource some of their tasks. The municipality can outsource their task of FRM to a specific organisation called a 'Schwellenkorporation' (water board). These water boards exist for the sole task of flood risk management. They are financed through so-called 'Schwellentellen': percentages of the value of the properties they have to protect. The percentages are higher for properties that are more exposed to floods. On top of this income, most projects are subsidised by the cantonal government (Matthias, 2018; Schai, 2018). Most water boards exist within one municipality, but the Bödeli Süd water board bundles six municipalities (see next paragraph). Having a water board benefits the municipality in multiple ways. The water board often consists of people with knowledge of the subject who can focus their attention on FRM. They get a certain amount of money, dedicated solely to FRM, without having to compete with other municipal goals (Kimmerle, 2018).

4.7 Gewässerrichtplan

This chapter has so far explained the federalist structure in which FRM is managed in Switzerland. As six paragraphs were necessary to explain the decentralised structure, some subjects become unmanageable. High water levels in streams for example, pass multiple municipalities, before diffusing into lakes or larger rivers. This is the reason for the cantonal government to decide to write Gewässerrichtplans (GRPs) (OIK I, 2013a, OIK I, 2013b). These plans are formed by a cooperation of the OIK (in the case of this study OIK I), with all local stakeholders (mostly municipalities and water boards) that are involved in the management of a river (catchment). In these GRPs, the water engineers describe all that needs to be done in the river catchment to overcome flood risk deficits and other problems, such as ecological and recreational deficits. By creating these GRPs, the OIK helps the local water engineers to see what needs to be done and to work together with other parts of the river catchment.

Two of the three river catchments in the case study region have a GRP. The Gewässerrichtplan Kander and the Gewässerrichtplan Hasli-Aare (OIK I, 2013a, OIK I, 2013b). The GRP of the Kander catchment is a very elaborate document, elaborately explaining eight overarching goals and 23 individual projects. These projects take place in all parts of the river catchment, from high up near the village of Kandersteg, all the way down to the Kander delta. In doing so, it makes ten municipalities cooperate on a very intense level, which is an important development in the very decentralised country. Mister Kimmerle (OIK, Kander) explains how the GRP works: "The gewässerrichtplan Kander now shows clearly, where which measures are necessary on which locations. Based on this gewässerrichtplan the municipalities and water boards can plan their own projects. Now we have an annual meeting with all the municipalities and water boards to see what the current situation of all projects is (2018)." The only municipality that is absent is that of Adelboden, because it is the

only municipality in the isolated valley of the Engstligen river. Kimmerle explains: "The Engstlige between Grassi and Adelboden is a natural park, which we cannot alter. There is hardly any infrastructure in that area. We want it to stay like that. There is no need for water projects there (2018)." As the GRPs are designed to make municipalities cooperate on matters that they cannot deal with on an individual level, the exception of the isolated village of Adelboden is understandable.

The GRP Hasli-Aare is a little less elaborate as it does not involve all municipalities of the Aare above lake Brienz (OIK I, 2013a). Only the municipalities of Brienz, Brienzwiler, Hofstetten, Meiringen and Schattenhalb have been involved, leaving out the municipalities of Guttannen, Innertkirchen and Hasliberg. The flood risk management situation in the municipality of Hasliberg is less important to the rest of the valley as there are no big rivers flowing through this municipality. The municipalities of Guttannen and Innertkirchen are located above the famous 'Aareschlucht' (Aare gorge), which forms a natural barrier to the lower part of the Hasli-Aare. The situation in these high-altitude villages is important to rest of the valley as the materials can be brought down and the fish ought to be able to go up. Mister Fahrni of OIK II disagrees with this statement saying that: "(...) after Innertkirchen is the Aare Gorge and below that we have a flat valley which can flood. The materials will not reach this part of the area. That`s why I always say: up until Innertkirchen you are in serious danger, below Innertkirchen you can be flooded, but you can also swim, so there is no life-threatening danger (Fahrni, 2018)." Apparently, the focus of the GRP is based on the bigger value of the lower part of the Hasli-Aare and its vulnerability due to its level surface. The choice to focus solely on the lower part of the Hasli-Aare in the GRP is understandable, as a smaller area is more handleable, but good cooperation needs to exist between the GRP area and the higher municipalities.

The Lütschine area does not have a GRP. As Mister Hitz (OIK I, Lütschine) states: "There is a list of ten to fifteen rivers that need such a plan. The Lütschine is on that list, together with the Kander and the Hasli-Aare. The other two areas have already started with this plan, whereas the Lütschine still has to start. The next years we will start with one as well (2018)." Soon, the OIK I will start to form a GRP document for this area, but the urgency was higher in the other parts. This prioritisation is explained by mister Hitz: "There is a prioritisation behind the list. We can`t make all the plans at the same time. This prioritisation is based on the problems at hand. The problems in the Haslital and the Kandertal were bigger than here apparently. The Kander even started with the plan before the revision of the law. Here in the Lütschinentäler are fewer municipalities that take part. On top of that we have good water boards that work together well. The cooperation was already existent. Therefore, it did not have the same priority here (2018)." The cooperation of which mister Hitz speaks mostly exists within the Bödeli Süd waterboard. This waterboard forms a cooperation of five municipalities in the Lütschine valley. Only the higher municipalities of Lütchental, Lauterbrunnen and Grindelwald have their own water board. The representative of the Bödeli Süd waterboard explained the exclusion of these higher villages: "It has been this way for 140 years. It works, so we keep it this way. (Matthias, 2018)." Later he adds: "We work together very well with different communities (...) The cooperation with different municipalities, also with municipalities that are not in our organisation works outstanding. Especially when waters flow over the borders of municipalities, I think cooperation is a must. The cooperation must not be too big to handle, however. That is the balance we must try to maintain. So why do we not add Lauterbrunnen, or Grindelwald? That is why. It would become unattainable to work together with so many municipalities." Although the cooperation is considered well by the local flood risk management practitioners, the coming GRP is likely to help the local communities to focus on different aspects than structural measures. This is necessary as the website of Bödeli Süd solely focusses on this narrow aspect of flood resilience (Bödeli Süd, 2019).

Chapter 5 Analysis Robustness

The following three chapters show a structured analysis of the data of the research (based on §3.6). Every dimension of flood resilience, as conceptualised by Restemeyer, Woltjer & van den Brink, forms a chapter (2015). Chapter five shows the results on the dimension of robustness, chapter six shows the results on the dimension of adaptability and chapter seven shows the results on the dimension of transformability. These chapters are structured by the different criteria that have been derived from the literature (see §2.2, §3.9 and appendix 1). The analysis of these criteria is divided into two sections, firstly the documents are analysed to show to what extent the local documents promote/constrain the respective criterion. Secondly, the interviews are analysed to check if the conclusions derived from the documents are visible in the everyday practice of the local flood risk management experts. Chapter five starts with a document analysis of the structural measures, which is then verified with an analysis of the interviews. The second half of chapter four follows the same structure but then on the subject of spatial measures. Together this analysis answers the sub question: `to what extent is robustness supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`.

5.1 Document Analysis of Structural Measures

The FRGA is for the most part based on the Gewässerrichtplan of each individual river (Kander and Hasli-Aare respectively) (OIK I, 2013a; OIK I, 2013b). The Lütschine does not have such a Gewässerrichtplan. Structural measures form a large part of the Gewässerrichtplan. Already in the goal definition of the Kander document the sentence "On the one hand, the waters are to be preserved naturally or close to nature, on the other hand, serious dangers that emanate from the waters are to be fended off (OIK I, 2013b; p. 1)" shows the significance of structural measures, as structural measures are of course part of the 'fending of' of serious dangers that emanate from the waters. The Gewässerrichtplan of the Hasli-Aare area shows even more focus on the structural measures. The goal definition in this document consists of three parts: flood prevention, condition of the dams and ecology (OIK 1, 2013a p. 1-2). Two of these three goals are for a large part about structural measures.

The Gewässerrichtplan of the Kander area takes a very holistic approach, not mentioning structural measures as a goal that can be separated from the ecological and recreational needs of the area (OIK I, 2013b). This is visible in the goal definition of 'flood protection': "Through a differentiated flood protection adapted to the use of the protection measures must have a good cost-benefit ratio and should be optimally linked to the valorisation of the living, economic and natural spaces (p.3)." This is elaborated upon by the statement: "The limited resources for water maintenance and ensuring the functionality of the bank protection buildings should be used targeting specific places and first priority must be given to places with a high loss potential (settlement areas, infrastructure facilities, etc.). In the remaining river sections, assessment and intervention lines should be defined instead of bank protection measures (p. 17)" The Gewässerrichtplan specifies the exact location of the main deficits in flood prevention (with a high damage potential) in the river catchment (p. 5). These areas do not yet reach the safety standards that are required by cantonal directive (BAFU, 2011). The mentioned areas are therefore the main focus of the structural measures in the Kander area. Specific projects are defined in the Gewässerrichtplan to overcome these deficits. The exact locations along the river are documented in the policy document and clearly marked on the overview map of the document (p.15). These projects are to be executed by the local municipalities or waterboards, depending on the governmental

arrangements within the municipalities (see section 4.6). The local people can prevent these plans from being executed by voting against the plans, as was the case in Frutigen (Bircher, 2018).

Many specific projects are defined in the Gewässerrichtplan Kander. Within the list of specific and local projects the following structural measures are listed: B1 Hochwasserschutz Kanderdelta, B8 Hochwasserschutz Reichenbach, B15 Hochwasserschutz unterhalb Kanderbrück, B16 Hochwasserschutz Kanderbrück, B17 Hochwasserschutz Rybrügg, B19 Flussaufweitung Ausserkandergrund, B20 Hochwasserschutz Kandergrund, B21 Hochwasserschutz Blausee and B23 Hochwasserschutz Eggenschwand Kandersteg. All nine of these structural measures are elaborately explained in the rest of the document. This documentation lists the involved stakeholders, the exact location, the deficits, the goals, the (ecological) circumstances, the documents and laws that are involved and the exact next steps. This documentation is clear as it shows which municipalities are involved and what they should do to fulfil the required safety (HQ) standards.

The Gewässerrichtplan of the Hasli-Aare area focusses on structural measures within the goals 'flood prevention' and 'condition of the dams' (OIK 1, 2013a). Within the goal definition of the flood prevention aspect, the previously described flood events (1987, 2005 and 2011) are named as examples that show the current safety levels are insufficient. This kind of events will only become more frequent because of the changing hydraulic and climatic circumstances according to the document (p.1), in line with the analysis of the federal government (BAFU, 2016). On top of these changing circumstances, the 'protective needs' that the cantonal government has decided upon have risen as well, necessitating a strengthening of the structural measures.

The Gewässerrichtplan Hasli-Aare differs from the Kander document in multiple ways. In some respects it is more elaborate (OIK 1, 2013a). It shows all the involved stakeholders on a national, cantonal, regional and (very) local level. The local stakeholders involve local companies that perform smaller tasks such as the extraction of materials from the rivers etc. Like the Gewässerrichtplan Kander, the Gewässerrichtplan Hasli-Aare contains a complete list of all the local structural measures that are to be completed. These are even more elaborate than the Kander Gewässerrichtplan and also form a very good basis for the local flood risk management practitioners to base their work on.

Aspects that are better explained in the Hasli-Aare document are that it explains the exact situation in a piece of text, supported by images of the situation in combination with a description of the involved stakeholders (OIK 1, 2013a). These details can inform people that have no previous knowledge on the local affairs, and thereby help create awareness. The spatial limitations of the document, that have been described in the context chapter, are constraining the cooperation within the entire catchment area, as the upstream municipalities are not involved in the document. The problems in this area are of a different nature, according to the cantonal experts (Stoffel, 2018; Fahrni, 2018). This argumentation is disputable and barely justifies the incompleteness of the document

The Lütschine catchment does not have a Gewässerrichtplan, which can be constraining to the robustness of the municipalities, as they have less coordination within this catchment. The Lütschine area will therefore get a Gewässerrichtplan, when the OIK finds the time to generate one (Fahrni, 2018). The necessity of cooperation is lower within this area, because most of this area is covered by one waterboard (SK Bödeli-Süd) (Matthias, 2018). Still, the absence of a coordinating document is a major flaw to the cooperation on

robustness (and other dimensions). The overall state of the structural measures in the Lütschine catchment is hard to assess, and parts of it, outside of the bigger water boards (Bödeli Süd, Grindelwald and Lauterbrunnen), seem to be lagging behind.

Document Evaluation of the Structural Measures			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
1.) Structural Measures (Robustness)	Structural measures do not show any heightening of the HQ in the area.	Structural measures have been taken to to heighten the HQ of the area, although the HQ is still below the safety standards. (Parts of the Lütschine catchment)	Structural measures have been taken to reach or surpass the safety standards. (Kander and Hasli-Aare)

Table 13: Document Evaluation of Structural Measures

5.2 Interview Analysis of Structural Measures

The interviewees have been asked about their view on the structural measures in their area with the questions: "please give examples of structural measures that lower the probability of flooding in the area" and "to what extent are these measures effectively lowering the probability of flooding in the area?" The first question aims to find out what the local authority has done to prevent floods when it comes to structural measures. The second question focusses more on how functional the local flood risk management practitioners think these measures are. The aim of this question is to find out if they are aware of the height of the HQ level in their area. These two questions are completed by the subjective questions: "what aspects of the FRGA in the area in which you are responsible are in your opinion exemplary for other mountainous areas when it comes to lowering the chance of flooding (strengths)?" and "what do you think are the main challenges for the local FRM strategy when it comes to lowering the chance of flooding in your area (weaknesses)?"

Structural measures are the main focus of all the local flood risk management practitioners. Therefore, the interviews give many important insights into this aspect of robustness. The following long citation by Adrian Fahrni (OIK I) gives a complete overview of the two main lessons that can be drawn from the interviews:

"We get the goals from the canton, so that certain areas that could have a more devastating consequence get better protection. The nuclear reaction here near Bern for example has a very, very high standard. In the Haslital we only have some villages, so most of the area is standardised with a goal of HQ100. More houses together means mostly HQ100. When smaller farmer groups are together then it goes down to HQ50 etc. We differentiate to fit the risks. The railways and the highway also have some extra protection. (...) In the Haslital we have a Gewässerrichtplan. This plan has a very elaborate structure and shows where which goals have to be set. This [document] also shows where the water will go when a flood occurs. One rule counts in all those plans. The protection [after new measures] will never become worse than it is today. So everyone wins, but some win a lot more than others. On top of that the plan shows ecology, material transportation etc. (2018)."

This extensive citation shows firstly that and how the structural measures are differentiated to efficiently lower the flood risk. Secondly it shows that new projects can never make any properties more vulnerable to floods. These two rules are important baselines in the evaluation of the rest of the structural measures. This citation also confirms the conclusion that was derived from the documents, that the structural measures that are being executed focus on existing deficits and that the GRP helps prioritize the future measures.

The differentiated norms that have been set are clearly visible in other interviews as well. Densely populated areas like the Bödeli Süd are much better protected than smaller villages like Kandergründ and Lütschental. The Bödeli Süd and Lauterbrunnen protection level reach up to HQ300, whereas some of the less populated areas only reach HQ30 (Matthias, 2018; Schai, 2018, Bircher, 2018). By differentiating the norms, the projects intend to leave some areas more vulnerable than others. This idea is morally debateable, but it argued that some prioritisation has to be made for efficiency reasons. Contradictory to the document analysis conclusion, that the focus of structural measures is solely to resolve local deficits, are the statements of both Matthias (SK Bödeli Süd, 2018) and Schai (SK Lauterbrunnen, 2018), who claim that the local aim is to withstand an HQ300 event. This is a very eager and progressive goal, rising above the official requirements and thereby going beyond the deficits.

Looking into the goals that have been set for the different areas, the differentiated norms are clearly visible. The reason for the two areas mentioned in the last paragraph to aim beyond their required safety standards is simple. The more populated areas, such as Lauterbrunnen and Bödeli Süd, have a very high damage potential and therefore have to be safe for a 1 in 300 year event. Other areas have a lower economic value and are therefore planned to be less protected. Lauterbrunnen and Bödeli Süd do not actually achieve their high standards yet: "We try with most of our projects to reach HQ300, so we can be safe for most flood events. Not everywhere, this is attainable, however. Further back in the Mattenbach we can only reach HQ100 for example, but we try mostly to reach HQ300. That is the goal, but it can also be very costly (Schai(Lauterbrunnen), 2018)." and "When we have finished all of our projects then the Lütschine will be HQ300. Right now we are still in the middle of these projects, so we do not reach HQ300 yet (Matthias (Bödeli Süd), 2018)." These examples show that the planned safety of the economically more valuable areas is high, but the projects still need time to be finished.

Many areas aim for HQ100, as the Gewässerrichtplan instructs them to. This is consistent with the cantonal law: "All municipalities have to stick with the cantonal plans of the Kander 2050 project. That means that all villages must reach the HQ100 aim (Bircher (Frutigen), 2018)." Most of the villages reach this goal: "I think most of the village is safe from an HQ100 event now. There are quite a few families living here and therefore there is quite some effort put into this area to safeguard it from future events (Teuscher (Lütschental), 2018)." and "All in all, along our village the HQ is now between HQ100 and HQ300, depending on the amount of material in the river (Banholzer (Innertkirchen), 2018)." The HQ100 safety standard does not vary between the different municipalities because it is embedded in the cantonal law (Fahrni (OIK II), 2018).

The height of the safety standards does not vary between the municipalities, but not all municipalities reach the safety standards that have been set by the canton of Bern. The municipality of Frutigen forms a prime example. Within the municipality of Frutigen, some areas that are densely populated, still do not reach the HQ100 goals. The following citation is therefore very troubling: "I think it [the flood resilience of the municipality of Frutigen, ed.] is very good, when we get to do the two major projects. Without these two projects we are not safe. Kandergründ [a populated neighbourhood, ed.] for example gets wet feet with a

flood event of HQ30. With an HQ100 (flood event) the entire village of Frutigen could be in trouble. The damage potential is very high of course! (Bircher, 2018)" The municipality of Frutigen has not acquired the consent of the local people to initiate the projects that the municipality requires to reach the goals that have been set by the canton of Bern. The reasons behind these lacking safety levels are explained in §7.2.

One structural measure that has frequently been built in the case study area is a retaining area (Hitz, 2018; Stoffel & Fahrni, 2018; Matthias, 2018; Teuscher, 2018; Schai, 2018; Banholzer, 2018). A retaining area is placed in most of the smaller, and steeper creeks, designed to hold back the materials (rock and wood) that come down with a storm. It prevents these materials from going into the main rivers and from blocking the bridges and can thereby prevent rivers from flowing out of their riverbeds. The materials of the retaining areas have to be extracted periodically, to keep the measures functional, which can be a costly endeavour. Retaining areas are structural measures that are specific to mountainous areas like the Bernese Oberland.

The structural measures that prevent a flood event from happening have to reach an HQ100 level in all of the villages of the case study area. This goal has been set by the canton of Bern (Fahrni, 2018). Some of the local flood risk management practitioners claim that their village will reach an HQ300 safety level, which is more than the canton requires and the Gewässerrichtplan aims for. The damage potential in these areas is very high, because of which the local flood risk management practitioners see enough incentive to raise the local safety levels dramatically to prevent flooding. Smaller municipalities mostly reach the goals (HQ100) that have been set by the canton. This is in line with the conclusions of the document analysis. The municipality of Frutigen is an exceptional case that does not reach the safety standards that were set by the canton. This is a troublesome case, urgently requiring change, whereas the rest of the interviewed municipalities do not show signs of lacking structural measures. The waterboards of Lauterbrunnen, Bödeli Süd and to some extent Innertkirchen prove to be very motivated to battle flood risks through structural measures. Other municipalities, like Kandersteg and Lütschental simply aim to reach the goals that have been set for them. The municipality of Frutigen stands out as a weaker example, not reaching the goals that have been set.

Interview Evaluation of Structural Measures			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
1.) Structural Measures (Robustness)	Structural measures do not show any heightening of the HQ in the area. (Frutigen)	Structural measures have been taken to to heighten the HQ of the area, although the HQ is still below the safety standards.	Structural measures have been taken to reach or surpass the safety standards. (All but Frutigen, with an extra high standard in Bödeli Süd and Lauterbrunnen)

Table 14: Interview Evaluation of Structural Measures

5.3 Document Analysis of Spatial Measures

Switzerland has a very innovative system, clearly showing which areas are most prone to flooding. This system is based on the Gefahrenkarten (danger maps). The danger maps show which area is extremely exposed (red zones), which area is exposed (blue zones) and which area is hardly exposed (yellow zone)

(BauG., 1985). Swiss law prevents people from building in red zones. In blue zones, people need special permission to be allowed to build. Buildings that are already in the red zone do not necessarily have to move. This can lead to dangerous situations as well as high potential damages. The second criterion for robustness therefore looks at the danger maps and evaluates to what extent activities still take place in endangered areas.

The GRP Kander names space for water development as one of its primary objectives (OIK I, 2013b; p.3). This is a very complex objective, with many aspects belonging to various aspects of flood resilience. The goal definition certainly has a spatial component, combined with natural and recreational aspects: "The space needed for measures to protect against flooding, as well as for securing and promoting the natural functions of the Kander and the Kander flood plains, is to be sustainably ensured (p.3)." The explanation of how the space for water development is to be situated shows the extent of the spatial measure: "The newly defined water development area includes the active width of the Kanders natural system, taking into account the existing restrictions and the legally valid building zones. It is based on the historically original Kander water area and has a width of 40 to 450 m, depending on the section. It is thus not congruent, and, in some sections, broader than that according to the Swiss Federal law, Canton of Berne Water plan Kander (GRP Kander) 5 and cantonal water protection legislation (p.4-5)." In this section the Gewässerrichtplan defines its ambitious goals on spatial measures. These ambitious goals are a good way of preventing damage, as a bigger riverbed means that less properties are endangered. It has to be noted, however, that this goal is still to be executed by the local responsible agencies with consent of the local people.

Seven areas are specifically named in the Gewässerrichtplan Kander as 'River widening' zones, namely: "B2– Flussaufweitungen Mündung Simme bis Hondrich, B4– Flussaufweitung Heustrich Mitte, B6– Flussaufweitung Reichenbach, B9 – Flussaufweitung Chalberglungge Kien, B10– Flussaufweitung Gand Kien, B12– Flussaufweitung Schwandi Ey and B19– Flussaufweitung Ausserkandergrund (OIK I, 2013b) ". These projects are often strategically situated near villages (Hondrich, Heustrich, Reichenbach, Kien and Kandergrund), to prevent the highest damages, but within natural (often forested) areas, so the most valuable properties can remain where they are. The individual projects name 'soil stabilisation' as their main objective, together with the ecological goals (OIK I, 2013b, p. 37). Soil stabilisation has a clear preventative influence on the flood risk, but this is not the only way in which river widening influences flood resilience. The positive effects of these spatial measures on the robustness dimension of flood resilience, namely the fact that a wider river can transport more water in case of emergency, are implied but not specifically named, which is surprising as it is one of the main reasons for the local implementers to execute the projects (see section 5.4).

The Gewässerrichtplan Hasli-Aare shows less interest in river widening. In two of its main objectives it names river widening as a means to reach these goals. The goals 'material management' and in the goal 'Flora and Fauna', 'river widening' is named as part of the solution (OIK I, 2013a; p. 45, p. 47). Only in two projects (the river delta project and in a smaller side creek) does it specify actual plans for river widening (OIK I, 2013a, p. 25, p. 99). The lack of interest in spatial measures within the Hasli-Aare area is surprising, as the river is very canalised in this area, with little room for natural dynamics and therefore much to gain from spatial measures, but at too high costs.

The danger maps (Gefahrenkarten) are available for free to everyone with access to the internet. A complete overview map is available on the website of the Canton of Bern (Geoportal des Kantons Bern, 2019). This map shows multiple insights that are very relevant to this study. The map shows that all three catchment areas are included, be it on different scales. The Kander area is a rather populated area, and it is well mapped out. The Lütschine area has some gaps in the map, within the less populated areas in the middle of the valley. The

Hasli-Aare area is well mapped on the lower parts and a bit more fragmented upstream. The danger maps show all kinds of natural hazards, from avalanches to landslides and floods. Fixating on the flood risk certain trends become clear. Most areas either have very low risk of flooding (transparent) or a low risk of flooding (yellow). Surprisingly, most of the Kander area is yellow or transparent, which is unexpected as the exploratory talks suggested this area to be most exposed. Also, most of the bigger villages in the other catchments are classified as transparent of yellow (Innertkirchen, Meiringen, Grindelwald and most of Lauterbrunnen). Some areas have a medium risk of flooding (blue) and therefore require special permission to be built in. Examples of villages and areas with a lot of medium flood risk areas are the lower Hasli-Aare area, Wilderswil and Kandergrund. A few, mostly upstream areas have a high risk of flooding (red). Examples of such areas are Eggenschwand (above Kandersteg), Stechelberg (above Lauterbrunnen), Lütschental, Saxeten (Above Wilderswil) and Gadmen (above Innertkirchen). It is important to note that this does not mean that these areas are necessarily much less flood resilient than the transparent areas. The danger levels mostly stem from the natural characteristics of a certain area. Some areas have no flood risk because of elevations in the landscape, making them unendangered without human intervention. The danger level of a certain area should therefore be seen as the natural danger that derives from the natural characteristics of the locality minus the human interventions that were made to lower this exposure. As the endangered zones are mostly very small villages, the red indication is enough to prevent high flood risk as it ensures the blockage of (economic) expansion. This is a good example of a functional spatial measure to enhance the robustness of the area. The danger maps do not indicate improvements on structural measures, nor relocations of valuable properties and can therefore not be seen as a final evaluative indicator. The map does show that some villages are at least mediumly endangered, incentivising local flood risk management practitioners to tenaciously combat the flood risks.

Somewhat surprisingly, the Gewässerrichtplans do not show any intention to relocate any built areas to higher, less exposed grounds (OIK I, 2013a; OIK I, 2013b). This is surprising as this would completely eradicate the flood risk. The relocation is a very costly endeavour however, explaining its absence. Combined with the view of the local people on such a drastic measure whilst considering their final vote in the matter makes the absence of relocation not surprising at all. Still, some flood prone locations would benefit from a relocation, based on their exposure to floods.

The Lütschine catchment does not have any specific documentation on the spatial measures but given the similarity between its danger maps and the danger maps in the other river catchments, there is no reason to believe there to be any difference in its functioning as the GRPs do not show much focus on relocation.

Document Evaluation of Spatial Measures			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
2.) Spatial measures (Robustness)	Spatial measures have not been taken to lower the potential damage within vulnerable zones.	Spatial measures have been taken to lower the potential damage within vulnerable zones, but some vulnerable objects still exist.	Vulnerable zones have been identified and cleared of valuable properties.

Table 15: Document Evaluation of Spatial Measures

5.4 Interview Analysis of Spatial Measures

The spatial measures indicator comes forth in the interviews through the question: "are the spatial planning measures (zoning, Gefahrenkarten etc.) effectively lowering the amount of economic activity in the flood prone areas?" This question is completed by the same subjective questions that also complete the structural measures aspect: "what aspects of the FRGA in the area in which you are responsible are in your opinion exemplary for other mountainous areas when it comes to lowering the chance of flooding (strengths)?" and "what do you think are the main challenges for the local FRM strategy when it comes to lowering the chance of flooding in your area (weaknesses)?"

The primary objective towards functional spatial measures in the FRGA that comes forth in the interviews is the intent to develop functioning danger maps. The main responsibility of the development of the danger maps is with the municipalities. The OIK supports the municipalities: "we as experts help the municipalities to make and to check the danger maps. (Hitz (OIK I, Lütschine), 2018)" The OIK also has a big part in the funding of the danger maps: "The municipalities have to make these cards, we fund them for 90%. The municipality has to do it, even though they don`t always want to (Fahrni (OIK II), 2018)."

The danger maps form a basis for the work of the decision-makers. An interviewee from the OIK explained: "Based on the danger maps we have a look at the possibilities to lower the risks and for that we then work together with the water boards (Hitz (OIK I, Lütschine), 2018)." This response shows that the danger maps play a vital role in the decision-making process. The value of danger maps has been illustrated in other interviews as well. Mister Schai of the waterboard of Lauterbrunnen explains how the danger maps have come about, with the use of the local expertise of the water board. He then claims: "We gave this (information) to an engineering bureau and they assessed what is really the most dangerous and what should be done first and now we are just starting at the top of this list and work our way down (2018)." In this manner, the robustness of the FRGA is actively increased, with a functional prioritization.

The zones that are most vulnerable are clearly shown on the danger maps. In these zones the local people are not allowed to build, lowering the damage of a possible flood. The responsibility for (not) permitting to build in these zones lies with the OIK. The following citation by a member of the OIK explains how the zones of the danger map work: "(…) a red zone means you cannot build, a blue zone means you need to take precautionary measures and you need to ask us for permission (see §6.7 and §6.8). Therefore, people want to change their village into less red zones. Especially the municipalities with a lot of red zones will therefore take a lot of action to make these areas blue (Stoffel(OIK I), 2018)." The danger maps clearly impact the economic value within the vulnerable areas and as the above citation by Schai shows they also make the prioritization of future action easier. On top of these two functionalities, the danger maps help the agencies that are responsible for the evacuation of vulnerable areas to know on which areas to focus. Finally, the precautionary measures that are required if one wants to build in a blue zone can be seen as a mitigation measure, which enhances the adaptability of the local community.

Some interviewees from the municipalities and waterboards are very positive about the functioning of the danger maps: When asked about the influence of the danger maps in Kandersteg, mister Weibel responded: "They are very good. The Gefahrenkarten are brand new (2016), so we have to see what they do in the future, but if anyone now wants to build in the red or blue zones then they have to ask special permission to the OIK, which they will not get easily. (2018)" In this manner, spatial measures can prevent people from

building in vulnerable areas. The example given by the interviewee is therefore promising for the functionality of spatial measures in the FRGA.

Not all respondents give the same positive impression of the usage of danger maps. Although the respondent from Lütschental agrees that the danger maps have a positive impact on the decision-making, he claims to have nothing to do with the formation of the danger maps (Teuscher, (Lütschental) 2018). The lack of input from the waterboards in the formation of the danger maps is confirmed by other interviewees, such as by Matthias (Bödeli Süd): "With the danger maps we have nothing to do (2018)." This implies that the local knowledge that this water board represents has not been used in this part of the decision-making process which then forms the basis for the rest of the decision-making. Other answers in the interviews disconfirm the lacking participation of the local flood risk management practitioners in the formation of the danger maps. Matthias (Bödeli Süd) for example contradicts his earlier statement, saying "we sometimes attend the meetings about the danger maps as we know most about the weaknesses in flood risk management and we can help the municipalities with these things (2018)." This not only shows that the waterboards sometimes are indeed involved in the formation of the danger maps, it also shows that they have a valuable contribution to make to this process.

Another problem is that the danger maps are not complete for every part of the case study area, as described in the document analysis. Sometimes the danger maps are also not completely up-to-date, which can restrict the economic expansion and the benefits of new structural measures. An example of this was given by mister Banholzer (Innertkirchen): "[the danger maps] need to be revised as the urgency is much lower due to the (implemented structural) measures. Our waterboard cannot revise them however, as that is the responsibility of the municipality, the fire department and the canton."

The danger maps are effectively impacting the economic value of vulnerable areas by not allowing the local people to build in the most dangerous (red) zones. The OIK controls the building permissions and the interviewees from this organisation are positive about the effects. Focussing on the building permits does not help to actively lower the (economic) value of the properties that are already within the vulnerable areas, as the case of an existing campsite in the red zone in Lauterbrunnen shows (Schai, (Lauterbrunnen) 2018). Buildings that are already within the most dangerous (red) zones are not forced to relocate, which is consistent with the conclusion in the document analysis, and must be considered somewhat short-sighted.

In sum, functioning and complete danger maps are a valuable asset to the robustness of the FRGA in multiple ways. They help to assess where strengthening of the structural measures is most urgently required, they lower the economic development in the most vulnerable areas, and they help to focus attention when it comes to evacuation plans and other adaptability measures. The current state of the danger maps in the case study area needs improvement, as they are sometimes incomplete or not up-to-date. On top of that, some local flood risk management practitioners, like Teuscher and Matthias criticize a lacking involvement of the local flood risk management practitioners in the formation process (2018). Finally, the refusal to try relocation as a means towards a more robust local society is understandable from a practical vantage point, but lacking from an ideological perspective.

Interview Evaluation of Spatial Measures			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
2.) Spatial measures (Robustness)	Spatial measures have not been taken to lower the potential	Spatial measures have been taken to lower the potential damage within vulnerable	Vulnerable zones have been identified and cleared of valuable properties.

	damage within vulnerable zones.	zones, but some vulnerable objects still exist.	

Table 16: Interview Evaluation of Spatial Measures

Chapter 6 Adaptability Analysis

Chapter six shows an overview of the results on the evaluation of the flood resilience dimension of adaptability. It is structured similarly as chapters five and seven. Firstly, the documents are analysed on the criterion of renaturalisation, followed by the analysis of the interviews on this subject. A similarly structured analysis follows on the criteria of insurance, evacuation plans and local protection. Together this analysis answers the sub question: `to what extent is adaptability supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`.

6.1 Document Analysis of Renaturalisation

Renaturalisation is very well documented in the case study area. Both overarching documents name multiple renaturalisation projects. The Gewässerrichtplan Kander for example, names 'ecology' as one of its six main goals (OIK I, 2013b, p. 3). This goal is explained as: "The Kander should have enough space for the self-dynamic development with water-typical structures available. Existing valuable habitats for animal and plant species in the sphere of influence of the Kander should be preserved, promoted and protected, and alluvial relics should be connected to the Kander. In addition to the river expansion, measures are needed to develop the structure of the water body." The definition of this ecological goal already shows a remarkably zealous drive to sustain the natural dynamics of the Kander river. The needs of the local natural ecosystem seem to be put on the same level as the needs of the local economy.

The ecological goal of the Gewässerrichtplan discusses renaturalisation most prominently, but other goals also allow for the promotion of natural dynamics (OIK I, 2013b, p. 3). The definitions of the goals 'flood protection' and 'water development space' also specifically mention the needs of the ecosystem stating "... (flood protection) should be optimally linked to the valorisation of living, economic and natural spaces (p.3)" and "... for the protection and promotion of the natural functions of the Kander and the Kander floodplains in the future required space is to be ensured sustainably (p.3)" respectively. This again shows the interwovenness of the separate goals of the document, with a focus on ecological values in almost all other parts.

The local projects that derive from the Gewässerrichtplan Kander clearly aspire to improve the ecological standards in the valley (OIK I, 2013b). Specific measures are mentioned to improve the conditions for the fish (p.21), wood is left in the river to support the natural dynamics (p. 22), endangered animals are protected (p. 23) and the riverbanks are replanted (p. 24). These measures are to be executed along the river, most rigorously at the river development spaces (see §5.3). Even the (structural) measures that do not directly aim to improve the ecological conditions, cannot impair the natural surroundings, and the natural areas that might be implicated in the action are clearly listed. These ecological measures have been planned for over a decade. A special document on the exact ecological deficits of every inch of the river Kander has been documented in the document "Kander.2050 – läbigs Kanderwasser (Lively Kanderwater)" (Amt für Landwirtschaft und Natur des Kantons Bern, 2007). This document stipulates that the needs of the natural surroundings of the Kander river ought to be taken seriously. Every plan that was to be considered, be it for flood management or for energy production, has to improve the ecological situation of the river (p. 84). The document 'Läbigs Kanderwasser' looks at the different ecological requirements of the riverbed and evaluates the situation of every kilometre accordingly. It evaluates the fish habitats, the vegetation, the water quality, the area

surrounding the river and the dead wood respectively (Amt für Landwirtschaft und Natur des Kantons Bern, 2007; pp. 22-52). In doing so, the document Läbigs Kanderwasser focuses solely on the ecological aspect of the river, which is to be applauded, as it is a very progressive outlook on the situation within the country. Considering all the attention for the ecological aspect of flood risk management, the Gewässerrichtplan Kander in combination with the earlier document "Lively Kanderwater" can be seen as very elaborate and stimulating documentation on the subject of renaturalisation.

The Gewässerrichtplan Hasli-Aare shows less awareness for the importance of the ecological aspect of river management (OIK I, 2013a). In total, the improvement of the natural circumstances is mentioned 34 times in the Kander document and only 12 times in the same document of the Hasli-Aare area. The document does state that there is a deficiency: "The ecological status of the Aare is unsatisfactory according to today's requirements. Both due to the social demands on landscapes and bodies of water, and to the dramatic changes to the legal framework conditions in recent decades (p. 30)." This recognition of a deficiency is followed up by the goal definition of 'Flora and Fauna': "The Hasli-Aare cannot be given space for a more dynamic development because of the limitation by the dams (modes of transport). Existing valuable habitats for animal and plant species in the area of the Hasli-Aare should, however, be preserved, promoted and protected, and alluvial relics and other existing, ecologically valuable habitats should be connected to the Hasli-Aare. The foreland between the dams is to be renatured." On top of this goal, ecology is again mentioned in other goals, specifically in 'recreation', 'agriculture' and 'material management' (p.33), which again shows the interconnectedness of the situation. In all of the specific measures that have been named in the document, the ecological situation has been taken into account, be it sometimes briefly. This is not coincidental, as the higher governments demand this to be done (Fahrni (OIK II), 2018). The (lower) Hasli-Aare is more canalised and is therefore harder to renaturalise then the Kander and the Lütschine, but the documentation shows that the will to renaturalise this area is adequately present. The documentation of the Kander area does clearly show more focus on the subject, however, which manifests in the number of renaturalisation projects in the respective areas.

The different documents on the Lütschine area ought to have similar focus on renaturalisation as the same laws requires it to be thusly. These documentations are very fragmented and therefore hard to analyse. The website of the biggest waterboard of this area (www.boedeli-sued.ch) does not specify the need for ecological restructuration in the area. It does however, show the consequences of each individual plan to its natural surroundings. The lacking overview documentation lowers the pressure on the local flood risk management practitioners to act on behalf of the ecological needs and must therefore be seen as suboptimal if not altogether erroneous, definitely in comparison with the exemplary documentation in the Kander catchment area.

Document Evaluation of Renaturalisation			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
3.) Renaturalisation (Adaptability)	The rivers are completely canalised with no regard to its ecosystem.	The ecosystem of the river has been taken into account and steps have been taken to its betterment. (Lütschine)	The ecosystem of the river has been restored to give the river and all its life more space. (Kander & Hasli-Aare)

Table 17: Document Evaluation of Renaturalisation

6.2 Interview Analysis of Renaturalisation

The renaturalisation aspect of adaptability is mentioned as an example within the first adaptability question: "can you give examples of measures that have been taken to lower the *potential damage* of flooding (evacuation plans/renaturalisation/insurance etc.) in the area?" This question is elaborated upon in the next question: "to what extent are these measures effectively lowering the *potential damage* of flooding in the area?" Similar to the intention of the robustness questions, these two questions focus first on the existence of projects, to then focus on their functionality. Finally, the interview inquires for a subjective understanding of the good and the worse parts of the local FRM when it comes to adaptability in general, allowing for additional insight on the subject. This subjective understanding comes forth in the questions: "what aspects of the FRGA are in your opinion exemplary for other mountainous areas when it comes to lowering the *potential damage* of flooding (strengths)?" and "What do you think is the main challenge for the local FRM strategy when it comes to lowering the *potential damage* of flooding in your area (weaknesses)?"

Renaturalisation is an important aspect of the FRM policy in the higher levels of governance in Switzerland. The importance of this aspect is explained as: "these revitalisation projects are just as important as the flood risk management measures themselves. We need to give the water some more space, so it can become more natural, ecologically better and also the soil can stabilise (Kimmerle (OIK I, Kander) 2018)." Mister Hitz of the OIK in the Lütschine area corroborates on this statement by stating: "Even the Canton and the National government try to do something. Renaturalisation projects are very well subsidised. In that way we try to move this (renaturalisation) along." These subsidies are sometimes noticed by the local waterboards: "My predecessor always said: These projects get almost complete funding from the canton, so do those to give something back to nature. So you do something against floods at one time and the next time you give something back to nature. We have done that quite a few times (Schai (Lauterbrunnen), 2018)." The local flood risk management practitioners from the OIK clearly agree with the importance of renaturalisation as it is uttered in the Gewässerrichtplans.

The focus on renaturalisation is also visible in the cantonal laws which forbid the local waterboards from further decreasing the ecological values of an area within new projects. This has an indisputable impact on the local scale. Mister Fahrni (OIK II, Aare) explains: "When it comes to fishes we also have some exemplary aspects. We work in a fish habitat. The law tells us to keep that in mind. Therefore the ecological conditions cannot decline due to our work. We have to therefore take measures to help the fish to live in our waters. The habitat will be better most of the times than it was (2018)." The following example from Lauterbrunnen is exemplary for the situation as explained in many interviews: "We want to make a fish steps there. The old waterfall (artificial waterfalls such as the ones in figure 5) there shows damages and we are not allowed to build waterfalls anymore, as they are not ecologically defendable (Schai (Lauterbrunnen),

Figure 5: Artificial Waterfalls in the Engstlige near Frutigen (own Observation, 16-09-2019)

2018)." This simple juridical measure to enforce renaturalisation, or at least to sustain the ecological conditions shows positive results on the local level. It is a good example of how the rules dimension of the PAA impacts the actor and resource dimensions (Kaufmann, 2017).

The laws that stem from the higher levels of Swiss Government clearly prioritize the stimulation of ecological health of the river systems. The previous paragraph shows that this does impact the local decision-making. The local expert interviewees do not share the same prioritization, however. They often prioritize robustness over ecological goals. Mister Hitz (OIK I, Lütschine) has encountered this problem: "Renaturalisation is a difficult theme. Most municipalities/water boards that are responsible for water management see their responsibility primarily as flood prevention. Water management should have two parts however, the prevention of floods and revitalisation. Mostly the second part only comes when there is a special opportunity for this. When people see that there is both a flood and ecological deficit, then one project can help both aspects. Pure revitalisation projects are very scarce (2018)."

The local flood risk management practitioners represent the local people, who display the same focus on robustness in spite of the ecological deficits. If the local people do not see the urgency of the ecological deficits, no specific renaturalisation projects will take place. Although the OIK does support the ecological vision of the higher layers of governance, they do not fight these local decisions: "In the water boards there is a meeting, where all the locals come together. They decide if something happens. When the people do not want it then it does not happen. We can make a plan without asking the local water boards. We never use this option however, definitely not for renaturalisation. When people are in serious danger we might do it, but that is it (Hitz (OIK I, Lütschine), 2018)." This is a remarkable statement, as it shows how path-dependency, is sustained on a local level, in the direct democracy of Switzerland (Coombs & Hull, 1998) The conservative preference of the local people is not questioned by higher levels of authority, even if they are the experts on the subject.

The local interviewees did name many smaller renaturalisation projects. Many creeks and areas have been revitalized, like the Reichenbach, Husenbach, Sytenwald (Hasli-Aare), Schützenbach, Rotenbach (Lauterbrunnen) and Interlaken airport (Bödeli Süd) (Matthias, 2018; Schai, 2018; Fahrni, 2018). Mister Hitz states: "Most of them are in the smaller creeks and not in the main river. There is reason to want that in the main river as well, but the waterboards do not feel for this very much." Often the fish in the big rivers do receive special attention. Projects that help these fish to survive, such as the placement of rocks and wood were mentioned in the Lütschine area and in the Hasli-Aare area (Matthias, 2018; Schai, 2018; Banholzer, 2018; Fahrni, 2018).

Some interviewees state that no renaturalisation projects have taken place within the area in which they are responsible. The waterboard of Kandersteg for example claims not to have any such projects: "there is simply no space. We need the little bit of land we have for the farmers. We do still have some natural areas, such as

in the Gasterntal (figure 6), but in the valley of Kandersteg we cannot do that. Reichenbach, lower, has an exemplary naturalisation project, we cannot do that (Weibel, 2018)." The waterboard of Lütschental also claims not to have any renaturalisation projects (Teuscher, 2018). Farmable land is limited in the harsh mountainous environment but renaturalisation does not require exorbitant amounts of space and can benefit the local community as well. It is a matter of prioritization that has not dawned on the local FRM practitioners.

Figure 6: The Gasterntal is still unharmed by human Intervention (Own Observation 03-08-2019)

Most of the municipalities have worked out the demands from higher levels of government for new projects that give more attention to the ecological needs of the river systems. Although the results seem promising, the urgency has not become apparent in the minds of the local flood risk management practitioners. Some municipalities have not shown any renaturalisation projects, whilst others have only implemented them in the smaller creeks. Both these situations are undesirable and need improvement. Contrasting to many other parts of the analysis, a grand discrepancy between the documentation and the interviews becomes apparent. The local flood risk management practitioners do not share the same prioritization when it comes to the importance of ecological recovery as the writers of the GRPs and the higher levels of government.

Interview Evaluation of Renaturalisation			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
3.) Renaturalisation (Adaptability)	The rivers are completely canalised with no regard to its ecosystem.	The ecosystem of the river has been taken into account and steps have been taken to its betterment.	The ecosystem of the river has been restored to give the river and all its life more space.

Table 18: Interview Evaluation of Renaturalisation

6.3 Document Analysis of Insurance

The documentation that has been used to evaluate the previous aspects of flood resilience do not express any interest in the financial situation after an eventual flood event. Although this seems dissatisfactory from the perspective of the literature that forms the basis of this thesis, it is understandable from the perspective of the actors involved in the previously used documentation. The situation after an eventual flood event does not fall under their responsibility, as they focus on prevention of flood damage and improvement of the general living conditions in the area. Therefore, different documentation had to be used to evaluate insurance. As the insurance laws are cantonal, no differentiation will be evident in this analysis. Still, the insurance situation is an important aspect of the adaptability aspect, which becomes apparent in the following short evaluation.

The insurance for private properties is obligatory in the Canton of Bern. Every building in the canton of Bern has to have a 'Gebäudeversicherung' (building insurance) (Gebäudeversicherung Bern, 2019). The costs of these insurances depend on the building material (wood or concrete) and the exposure to natural hazards (danger maps). The fact that every house is privately insured is to be seen as positive, as it allows the local people to rebuild after a flood, preventing a flood from destabilising the local community, which complies with the previously given definition of flood resilience.

Two special remarks have to be made on the functioning of insurance in the area. Firstly, the private insurance companies have the option to lower their payments after a flood, if a flood has happened before and a private individual has not done anything to prevent damage from occurring (Mantel, 2012). In this case the insurers can recommend people to for instance place valuable properties in higher stocks. If the local people do not listen to these recommendations, they will not get a full payment again. This is an efficient rule that gives back some of the responsibility to the private owners. A second remark that is important to present is that in some extreme situations the private insurers cannot afford to give all the private property owners back their money. In this case the canton and even the national government can decide to step in and help the local people to rebuild the damaged villages, as was the case in Lütschental in 2005 (Balmer, 2006). This ensures a quick revival after an extreme flood event such as the 2005 floods. The insurance situation can be seen as outstanding in the entire case study area, as every building has to be insured, with a little responsibility for the local owners and certainty of help, thanks to the cantonal government. No differences between different parts of the Bernese Oberland can be discerned, as the insurance situation is a cantonal affair.

Document Evaluation of Insurance			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
4.) Insurance (Adaptability)	No financial means are available to undo the damage of a flood.	Financial means are available to undo the damage of a flood, but the availability is unclear or requires a lengthy process.	Financial means to undo the damage of a flood are available to all victims of flooding.

Table 19: Document Evaluation of Insurance

6.4 Interview Analysis of Insurance

The interview questions on insurance follow the same structure as the renaturalisation questions. The financial situation in case of a flooding does not fall under the responsibility of the local flood risk management practitioners that have been interviewed for this research. Still some noticeable answers have been recorded, that indicate the functioning of this part of adaptability.

Mister Teuscher of the waterboard of Lütschental gave the following overarching statement: "everyone can insure themselves, and we also have the buildings insurance, so people are very well insured in the area (2018)." The building insurance is explained further by mister Banholzer (SK Innertkirchen): "We have a cantonal insurance for the buildings. People need to do something about floods. Property owners get payed the first time they get damage, but not a second time and definitely not a third time, so when something happens you need to make sure it doesn't happen again (2018)." It seems therefore that the insurances do

what they ought to do; they allow people to rebuild after a flood event. On top of that, the insurances give incentives to involve people in the prevention of future flood damage. The document analysis also showed this aspect of the local insurance laws. Another way in which the financial situation stimulates the lowering of flood risk is that the more vulnerable households pay more for their protection to the local water board or municipality. Mister Weibel explains: "Every household and private institution has to pay a certain percentage of the worth of the protected property to us. For example, a household in a flood prone area is worth 200.000 Swiss Francs and has to pay 0.006 per cent to us. Then we get 120 CHF to use for protecting the municipality (2018)." The percentages are higher in a more vulnerable area, incentivising flood protection and spatial measures. As the document analysis showed, the insurance costs are also higher for properties exposed to natural hazards. A property owner in a red zone therefore pays more to the insurance company and to the water board, which is very incentivising, but must also be considered morally crooked, as it can be regarded as discriminating and double over.

After the major floods of 2005 the state helped the municipalities that suffered the biggest damage to rebuild. An example of such a municipality is the very small municipality of Lütschental. Mister Hitz (OIK I, Lütschine) explains: "They were hit really hard by the 2005 floods. So they needed urgent help. This was too much for their financial means so they were subsidised heavily by the state and the canton. Normally Lütschental would not be able to spend this much on flood risk management, but now the problem was very urgent (2018)." Mister Teuscher (SK Lütschental) confirms this stating: "In 2005 the national and cantonal government took 99 per cent of the damage, so we could survive, to clean up. Right now when a retainer fills up it costs us a lot of money. We are a small municipality so we do not have much financial means, so then we ask the canton for help (2018)."

The interviewees appear to unanimously approve of the current situation when it comes to the financial situation after a flood event. As they do not have the responsibility to check the exact status of this aspect of adaptability, their claims do not form conclusive evidence to verify the validity of the claimed good status of the financial situation. Following this statement, one conclusion can be made; As the theory suggests that the insurance is a vital part of the rebuilding after a flood event, the local flood risk management practitioners should be more informed about this part of the policy. Preferably they should also be involved in the decision-making on this aspect. Besides that, for as far as the acquired information is able to tell, the insurance situation seems healthy in the Bernese Oberland, actively incentivising lower risk options.

Interview Evaluation of Insurance			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
4.) Insurance (Adaptability)	No financial means are available to undo the damage of a flood.	Financial means are available to undo the damage of a flood, but the availability is unclear or requires a lengthy process.	Financial means to undo the damage of a flood are available to all victims of flooding.

Table 20: Interview Evaluation of Insurance

6.5 Document Analysis of Evacuation Plans

Evacuation plans are not part of the Gewässerrichtplans (OIK 1, 2013a). Multiple criteria can be used to evaluate the current state of the evacuation plans in the area, however. Firstly, the exact impact of an eventual flood has to be explored and mapped. Secondly, people need to be warned that an evacuation plan is being put into action. Thirdly, evacuation plans have to be available and accessible for the local people, so they know what to do when an evacuation plan has been put into action. The first step has been evaluated in the paragraph on spatial measures, as the danger maps form a good basis for the evacuation plans. The second and third steps are evaluated here.

A good warning system is important, as people need to be alarmed in case of emergency. The current situation of the possible natural hazards are clearly shown on multiple media. Naturgefahren (www.naturgefahren.ch) for example shows the current risks of forest fires, avalanches, floods, frost and storms. This website distinguishes between different levels of emergency (green, yellow, orange, red and purple), showing people the need to be prepared for action. The application is brought to the people through popular mobile apps such as the MeteoSwiss app. People living in the most flood prone areas of the city of Bern and around lake Thun can opt for a warning SMS, to warn them in case of upcoming floods (Stadt Bern, 2019). This progressive warning system is not in place in the case study area yet. The case study area therefore only has a warning system consisting of classical sirens. The villages all have a siren that goes off in case of extreme emergency (BABS, 2019). Some of the higher, more isolated valleys have to be reached by cars with sirens to alarm them, which is suboptimal, as this might be too late. In case of a major emergency, most people will be warned. Smaller crises could not trigger the sirens, leaving the most exposed uninformed, and the more isolated areas do not have access to the primary warning system. Apart from these two lacking particulars, the general operating of the alarm systems in the area is annually tested and functional. A detail that did not come forth from the document analysis, nor from the interviews, is that most rivers in the case study area are actively monitored. Special measuring devices, that were observed during the site-visits, show the height of the water level in these rivers (figure 7). Some of these can be accessed through the internet (hydrodaten.admin.ch) and can inform the local people on the seriousness of a flood situation.

Figure 7: Water Level Measuring Device near Kandergrund (Own Observation 15-09-2019)

The local people need to know what to do when they are warned. For this reason, evacuation plans need to exist and be available to the local people. The responsibility for this part of flood risk management lies primarily with the municipalities (Gemeinde Führungs Organ (GFO)), who can collaborate with other municipalities to form a regional emergency managerial organ (Regional Führungs Organ (RFO)) (POM, 2019). These local organisations lead the emergency planning and thereby the evacuators (often fire brigades). The evacuation plans are formed together with these local executors. Sometimes these evacuation plans are even practiced, such as in the case of Mitholz, to see if they function as they should and to perfect the plans (Frutigländer, 2019). This is a good way to improve the plans and to make them known to the local inhabitants, but the number of these exercises is unknown. On top of their leading role in the execution of the evacuation plans, the GFO/RFO can warn the local inhabitants to relocate their valuable properties to

higher stocks, to take measures and to be prepared for evacuation, as happened in 2007 (Marti, Gertsch & Iseli, 2007). The main responsible agency that gives out warnings for floods is the national BAFU (AG NAGEF, 2013; p. 32). The evacuation plans are not public, because that is considered a security risk (Bedetti, 2010). If terrorists have access to these plans, their damage potential grows, as they are able to cut off emergency routes and see which objects are vulnerable. The unavailability of the evacuation plans to the local inhabitants can obstruct the swiftness of the evacuation operation, however. The local inhabitants that have not knowledge of a possible evacuation procedure are instructed to 1) leave the endangered area, 2) to listen to the radio for further instructions and to 3) alarm neighbours (BABS, 2019). This is a rather limited instruction for proper evacuation plans, and it is therefore advisable to distribute more information, despite a possible threat of a damaging terrorist attack.

Document Evaluation of Evacuation Plans			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
5.) Evacuation Plans (Adaptability)	No evacuation plans are available.	Some evacuation plans are available but the execution is not known to all people involved.	Evacuation plans are available and well distributed and practiced.

Table 21 Document Evaluation of Evacuation Plans

6.6 Interview Analysis of Evacuation Plans

The interviewees are asked about the existence of evacuation plans using the same main questions as the renaturalisation and insurance aspects. On top of this the local flood risk management practitioners have been asked how the local people are made aware of the risks they have to live with. Evacuation is mentioned as a step that cannot go without the creation of awareness. The question "how are the local inhabitants involved to make them aware of the flood risk? (so they can take their own responsibility in lowering the potential damage and so they know how to escape a flood in case of an emergency)" is therefore very important in this context.

The evacuation plans are created by a combination of different organisation, with a leading role for the municipalities. "The municipalities need to make the emergency plans. The municipalities can base these on the Gefahrenkarten. The fire department then has to make sure the emergency plans are functional. That all works well in the canton Bern (Kimmerle (OIK Kander), 2018)." The creation of the evacuation plans is primarily in the hands of the fire department, but some waterboards actively participate in this process as well, such as the waterboard of Lauterbrunnen: "Yes, we have evacuation plans. The fire department has to make those and they are also responsible for the execution of these plans. (…) We were one of the first to participate in this. That should work. (…) So normally we have the notfallplanung (emergency planning) and per extension some special cases (Schai (Lauterbrunnen), 2018)." In this manner, the expertise of the waterboards can be used in the formation of the evacuation plans, to make sure all the people are safe in case of flooding. Mister Schai's claim regarding the participation of his local water board in the emergency planning is more positive than the document analysis suggested. The OIK also has a part in the monitoring of the quality of the evacuation plans. Oliver Hitz (OIK) states: "we are also responsible for the permissions to

build in dangerous areas, so we can ask for better evacuation plans etc. (2018)." All in all, the formation of the evacuation plans is a formidable endeavour displaying functioning cooperation of multiple stakeholders.

The execution of the evacuation plans is hard to evaluate as every incident requires a different protocol. Teuscher (SK Lütschental): Yes, since 2005 we have made evacuation plans in cooperation with the fire department. We have not been able to try these yet, as we have luckily not been endangered since then, but I think they work well (2018)." The main responsibility for the execution of the evacuation lies with the fire department. The fire departments take their responsibility seriously as the following citation clarifies: "The fire department is very well equipped and they are trained for those cases. Even the campsite has evacuation plans, so everyone knows who is responsible for which part of the evacuation (Hitz (OIK I, Lütschine), 2018)."

The cooperation of the fire department and the GFO/RFO with the local water experts during an event is splendid, as explained by Matthias (SK Bödeli Süd): "During an event we are not needed. We have no say in what happens then. We do have a Schwellenmeister and she is there. On top of that we are almost always at the spot. We do not have to, but we know what is happening and we want to know how it works. When a real event happens the first call goes to the fire department and if it is too big for them to the RFO. They know we are there, however, and we have some knowledge. We tell them what the problems are as well. It is almost family (2018)." Although the execution of the evacuation plans does not fall under the authority of the local water experts, they claim to be actively involved. On top of that possible evacuations are well planned and practiced in advance.

Figure 8: Evacuation Plan of Campsite Grassi in Frutigen (Own Observation 05-09-2019)

The final step is the creation of awareness among the inhabitants of the vulnerable areas. The evaluation of this step is hard as different opinions have surfaced. On top of that, the creation of awareness has multiple facets, some of which can be considered as enhancing transformability, rather than adaptability. The previous citations about the practicing of evacuations supports the idea that the local inhabitants are actively made aware of the local risks. The site visits have also shown evacuation plans on a local campsite (see figure 8). The owner of the campsite claimed that the municipality had required him to make the evacuation plan. Schai (SK Lauterbrunnen) does not see the need for more awareness: "The local people know about the dangers of living in this area. With all the dangers we have, they learn soon enough (2018)." Awareness of such dangers comes with the actual exposure to these dangers, which is often too late to prepare for it. The awareness only comes after a flood event in this case. "When a flood event has happened then the people all agree that something has to happen. I have read an article that says people forget an event like that in about seven years. When there is no event the awareness is lower, but people are still made aware through for example the gefahrenkarten etc. (Matthias (Bödeli Süd), 2018)." The question about the awareness seemed to worry some of the interviewees. Matthias even names the creation of awareness the biggest challenge for his water board.

Most of the interviewees consider the evacuation plans to be well planned, even though it is not strictly their responsibility. The part the local flood risk management practitioners play in the creation of the plans could be bigger, with varying results between the municipalities. The documents suggest this to be more of a problem than the local flood risk management practitioners admit it to be. The creation of awareness of an eventual flooding turns out to be difficult and challenging, requiring effort in the near future. The evacuation plans are practiced and well planned, however, making the evaluation of this criterion positive.

Interview Evaluation of Evacuation Plans			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
5.) Evacuation Plans (Adaptability)	No evacuation plans are available.	Some evacuation plans are available but the execution is not known to all people involved.	Evacuation plans are available and well distributed and practiced.

Table 22: Interview Evaluation of Evacuation Plans

6.7 Document Analysis of Local Protection

The cantonal law in the canton of Bern states that no new building zones are to be developed in areas that are exposed to natural hazards. It builds on article 6 of the building law and the danger maps that have been described in the chapter on spatial measures (BauG. Art. 6, 1985). The website of the canton of Bern does give another option, however: "If a spatial planning solution is not available, the risk of new or modified hazardous areas must be minimized by means of object specific safety measures. (Kanton Bern, 2019)" These local protection measures (or object protection measures) are difficult to evaluate, as they exist on a very small scale, from little mounds of land to the smallest culverts. The municipal and regional actors have little say in this mostly private endeavour. Therefore, this document analysis does not look at what local protection has been implemented, but on how local protection is promoted on a cantonal level.

The main promotion of local protection measures is of a juridical nature. Within red (very exposed to natural hazards) and blue (exposed to natural hazards) zones, no changes to existing or new buildings may be done, except if this lowers the risk of the natural hazards. It is formulated thusly: "In the red/blue hazard area, construction is only permitted if it is ensured with measures for the prevention of the endangerment of humans, animals and substantial material assets. Modifications and changes of purpose are only permitted if the risk is thereby reduced (Kanton of Bern, 2019)." Local protection measures in the yellow (hardly exposed to natural hazards) zones are the responsibility of private owners. This is the interpretation of the official law which is formulated as "For construction projects in red and blue hazard areas and for particularly sensitive construction projects in yellow hazard areas, the client has to prove that the necessary protective measures are taken (BauG. Art. 6.5, 1985)". 'Particularly sensitive construction projects' are constructions that are occupied by a lot of people (such as hospitals) or that are very valuable and vulnerable (such as IT facilities). By specifying these sensitive constructions, the more valuable objects are better protected, which promotes efficiency. The juridical measure to promote local protection measures is administered by the OIK, who give out the building permits, making the control simple and thereby adequate.

Within less exposed (yellow or transparent) zones local protection measures are the responsibility of the private owners of the (non-sensitive) construction (Kanton of Bern, 2019; BauG. Art. 6.5, 1985). Local protection measures in such areas have their own profitability for the owners as their property has less exposure to natural hazards. On top of this inherent motivation, insurance companies and experts support local protection: "expert advice and incentives from building insurance companies already show in this regard (object protection) a stimulating effect (AG NAGEF, 2013; p.30)". Section 6.3 has confirmed this statement. These measures are therefore not promoted or subsidised in any way by the government. The cantonal government could decide to promote this, financially or otherwise, but as the risk is rather low in these areas, there is little urgency for such interventions. The juridical obligation to erect local protection measures in case of a vulnerable object or an exposed location seems a satisfactory tool for the promotion of local protection. Existing objects are not obliged to comply to this rule, however, creating a loop hole in this furthermore fine solution.

Document Evaluation of Local Protection			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
6.) Local Protection (Adaptability)	No local protection measures have been undertaken.	Some local protection has been implemented, but not structurally.	Valuable properties in vulnerable areas are well protected individually.

Table 23: Document Evaluation of Local Protection

6.8 Interview Analysis of Local Protection

The interview focusses on local protection measures with the questions "how are the local inhabitants involved to make them aware of the flood risk? (so they can take their own responsibility in lowering the potential damage and so they know how to escape a flood in case of an emergency)" and more directly with the question "do you see any flood proof building in the area?" The first question focusses on the efforts that have been made to improve the local protection through FRM policy. The second question is meant to inquire about the resulting measures that have come about because of the stimulation through the FRGA. A second option to name local protection measures has been built in with the general adaptability questions that have been explained with the other criteria for adaptability.

Local protection is protection that is on an individual (property) scale instead of on a community scale. Traditionally most of the protection measures have always been on an individual level as explained by Fahrni (OIK, 2018): "I think the water boards also stem from the old laws from before 1989. In those laws the local property owners had to do their own part in the flood risk management. If you lived next to the river, you had to make sure that your land was safe. This meant you had to do some handwork as well as pay some fees. Because the local property owners could not do this all by themselves, they formed water boards to cooperate on this." Contrary to this traditional way, most of the protection measures within the case study area are now (at least in part) realised by the local flood risk management practitioners that have been interviewed. This section looks at the stimulation of those measures that are not initialised by these local flood risk management practitioners but by the local people, often because damage to individual properties would be extremely high. The local flood risk management practitioners can have an impact on the stimulation of these local measures, however. The inquiry into the extent to which the local people are made aware, which can be found in §6.6 is

as relevant here, as it is within the subject of evacuation plans. It is placed there for the simple reason that the section on evacuation plans is the first paragraph in which it is relevant.

Local protection measures are hard to monitor. Some very nice examples came to light. Mister Weibel (Kandersteg) explained how the local protection measures have improved: "We tell the property owners where and when they are in danger. When they live near the Kander, they will be told by the Canton to do certain measures. They have to for example close of all windows on the lower grounds to prevent water coming into the cellars. Almost all people listen to this, because otherwise the insurance does not help them. In 2005 this did not function very well yet, but in 2011 this has proven to work very well: only a few cellars still flooded in 2011." It is noteworthy that the 2011 floods were smaller than the 2005 floods, but the example does give an insight into the changes that have come about in the area, focussing on local protection measures. The citation following this example shows how well the local flood risk management practitioners understand the prioritization and the different aspects of flood resilience: "In short we have to make sure firstly that the Kander does not go out of the riverbed. Secondly that if it does, we have to make sure it does not come in the valuable areas and thirdly that the damage if it does is as low as possible (Weibel, 2018)." This is a short version of the understanding of flood resilience this research is looking for. The second aspect can be achieved using local protection.

Local protection is not always supported within the case study areas. A reason not to support it is that it does not always seem a functional option. Sometimes local protection is claimed to be impossible, such as in Lütschental: "It is difficult to make sure you don't have damage. When for example the water here from above comes down then we have water on three sides and there is not much we can do (Teuscher, 2018)." Mister Teuscher does not know about any flood-proof building in his municipality and neither does mister Schai (SK Lauterbrunnen): "No, nothing comes to mind. With avalanches we do have that, but not for floods that I know. When someone lives in the red zone, he simply cannot build. I don`t know if he would be allowed to change his building to make it more stable." These examples show that the refutation of the possibility or existence of local protection measures is more common among the local flood risk management practitioners than its stimulation.

However promising the example from the village of Kandersteg (Weibel, 2018) looks, the other local flood risk management practitioners deny the stimulation of local protection measures (Teuscher, 2018; Schai, 2018). As mister Weibel states that the cantonal authorities and insurance companies stimulate the implementation of local measures, it is probable that this stimulation is unknown to the other local flood risk management practitioners and per extension to the local people. This ought to be regarded as a missed opportunity. The case illustrated by mister Weibel can serve as an example for the other communities within the case study area, to further increase the local protection of vulnerable and valuable properties, and to thereby enhance the adaptability of the region. The OIK supports the use of local protection, but their enthusiasm is yet to trickle down to some of the local water boards.

Interview Evaluation of Local Protection			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
6.) Local Protection (Adaptability)	No local protection measures have been undertaken.	Some local protection has been	Valuable properties in vulnerable areas are

		implemented, but not structurally.	well protected individually.

Table 24: Interview Evaluation of Local Protection

Chapter 7 Transformability Analysis

Chapter seven shows an overview of the results on the evaluation of the flood resilience dimension of transformability. It is structured similarly as chapters five and six. Firstly, the documents are analysed on the criterion of lessons learnt, followed by an analysis of the interviews on this subject. A similarly structured analysis follows on the criteria of future challenges and experimentation. Together this analysis answers the sub question: `to what extent is transformability supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`.

7.1 Document Analysis of Lessons Learnt

Major floods have devastated the local communities in the Bernese Oberland in the past. Hopefully, these events have led to changes in the flood risk management strategy to prevent such catastrophes from endangering the area again. The Gewässerrichtplan Hasli-Aare clearly shows the impact of the past floods on its goal definition. The main reason for the urgency of new flood defence measures is formulated as: "The flood events of 1987, 2005 and 2011 clearly showed the weak points of the Aare-Korrektionsbauwerk. On the one hand, the dams have aged, on the other hand, the drainage capacity according to today's requirements and drains is insufficient (OIK 1, 2013a p. 29)." The Gewässerrichtplan Kander does not specifically name these flood events as a trigger to accelerate its formation and implementation. Instead it names the 'Kanderdurchstich' (see figure 9), a gigantic water diversion plan from the year 1714 as the main reason for action (OIK 1, 2013b; p.1). The Kanderdurchstich was a large project which bypassed a hill to make the river Kander flow through the Thunersee, and to thereby lower the chances of flooding in the city of Bern (Summermatter, 2012). Although this project was finished over 300 years ago, its consequences on the local material household and therefore the erosion within the Kanderarea, are still problematic today. As the project is over 300-years-old, the lessons drawn from its consequences are not to be considered 'lessons learnt' within the scope of this thesis.

Figure 9: The Kanderdurchstich today, visible as a giant Gorge in the Landscape, still causes erosion (Own Observation near Gwatt, 14-08-2019)

On a large scale the 2005 floods, and every large flood since, have been neatly analysed for future reference. Every major flood is analysed in an 'Ereignisanalyse' (incident/event analysis). The 2005 analysis gives clear information on what exactly happened to cause the flood event, what the damage was and what can be done in the future (Bezzola & Hegg, 2007; BAFU, 2008). Sadly, it is not specific for the case study region, but analyses the event on a national scale. It does state that the event was particularly extraordinary in the Bernese Oberland (p.9-10, 50). The Kander and Lütschine 2005 situations fell in the category of HQ200+ events,

whereas the situation in the Hasli-Aare area was considered to have been an HQ100 event (p.55). The municipalities of Reichenbach (Kander) Kandersteg (Kander), Lütschental (Lütschine) and Grindelwald (Lütschine) are listed as the most damaged municipalities in the whole of Switzerland. The Ereignisanalyse shows some well-functioning aspects of the state of flood risk management in 2005, such as: "It has generally been shown that observers on site were a very valuable help. The quality of the information collected can generally be described as satisfactory to good. (p.69)" Part two of the Ereignisanalyse shows more in-depth information on the functioning of the different processes. Multiple lessons are drawn from the event, to improve the flood resilience on a national scale. Examples include: "therefore (...) appropriate training efforts are necessary, be it to train existing officials or introduce new ones to their task (p. 344)", "Nevertheless, media continue to need information from professional circles and from intervention forces. They depend on sources that are professional and provide appropriate information. (p. 370)", "It is recommended that competent authorities carry out a thorough stakeholder analysis prior to the preparation of a danger map, with regard to the entire process from preparation to implementation. (p. 383)" and finally "The hazard assessment and the derived hazard map are and will remain the central basis for dealing with natural hazards. During the implementation, the focus is increasingly on the interactions of different actors. (p. 385)" These lessons, that have been drawn from the 2005 floods, are to be implemented on a national scale and can dramatically improve the way in which the authorities deal with a comparable situation. A thorough analysis of a flood event is an important part of the learning trajectory after a flood event. The scale of the revision points can hardly be seen as useful for the local flood risk management practitioners, however. Therefore, a more local (municipal or preferably regional) analysis of the major flood events would be a considerable improvement on the current flood risk management situation and is hereby recommended.

Document Evaluation of Lessons Learnt			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
7.) Lessons Learnt (Transformability)	The floods have not been evaluated and similar circumstances would result in similar damage.	The floods have been evaluated and some action has been taken to lower the impact of a similar event.	The floods have intensively been studied and measures have been taken to prevent flooding in similar circumstances.

Table 25: Document Evaluation of Lessons Learnt

7.2 Interview Analysis of Lessons Learnt

The criterion 'lessons learnt' forms an abstract but important part of the transformability dimension for the local flood risk management practitioners as well. The first step to an understanding of the lessons that have been learnt from previous floods is to understand how these floods have impacted the area. This is a direct question in the interviews: "Can you explain the impact of the last floods in the area in which you work?" The answers to these questions cannot be anticipated but have formed a basis for further questioning in the interviews. The elaboration on this question in combination with the final question: "to what extent do you think the area is prepared for future flood challenges?" has allowed for a good understanding of the implementation of the lessons learnt in the FRGA.

All of the local flood risk management practitioners can recollect the terrible flood events in 2005. This shows the impact of these events. Lütschental was one of the villages that suffered the biggest damages: "Here just above the Bahnhof everything was flooded and big parts of the road were gone. It was really bad at the time. On top of that all of the small creeks were very high and flooded the area as well. It truly was a catastrophe. All we could do was help the people to reach a safe place (Teuscher, 2005)." Some floods occurred in 2011, causing some damage, but not as devastating as the 2005 floods: "The 2005 flood was the biggest flood event in the region. That was very damaging, but we also had the 2011 floods that was probably when we look at the amount of water even bigger here (Lauterbrunnen). I think maybe the 2011 floods were a bit more local than the 2005 floods, but here we also had some big damages in 2011 (Schai, 2011)." The 2011 flood event was a more local event that hit the Kander and Lütschine areas more than the Hasli-Aare. Kimmerle (OIK) says about the Kander area: "I think (the damage) was around 30 million Swiss Francs. It (the flood) was definitely the biggest of the last years. We had a few middle large events, like in 2014, but the damages were not as big anymore (2018)." The 2011 flood is considered to be the last major flood event in the area to this moment. The lessons learnt can therefore stem from both the 2005 floods and the 2011 floods.

The interviewees almost unanimously recognise major improvements since the beforementioned flood events. Generally, the biggest deficiencies that caused the major damage then have been solved to some extent. The following citations are a few of the many examples: "For example in Kandersteg we saw big floods in 2005 and 2007 which gave them enough incentive to initiate the projects. These projects were almost finished in 2011 and prevented a lot of the damage in the village there ((OIK Kander) Kimmerle, 2018).", "In 2005 our measures were not good enough yet. In 2011 we just prevented a major catastrophe and now we should be safe with most floods ((SK Kandersteg) Weibel, 2009).", "The water boards take it seriously and have taken a lot of action since the floods of 2005 (Hitz (OIK I, Lütschine), 2018).", "Since 2005 we changed everything (...) Since 2005 the Lütschine has been given more space (...) Right now we think (and the canton thinks) that we have done what we have to do. Everything that needed to be changed since 2005 is changed and the whole project was finished in 2013 (Schai (SK Lauterbrunnen), 2018)."

Only one municipality within the case study area does not show the required action. The municipality of Frutigen has not yet implemented the changes that need to be implemented. The cause of this lacking action is described by the local expert in the following citation: "Sadly, the local people voted not to grant us the money. They disliked the lengthiness of the planning process and the local people that live right next to the Kander did not want the river course to change, because that would mean they would no longer live next to the river. These people convinced the rest of the town to vote against the plans and now we have to start all over again and the planning process will take even longer. The projects should start 2020, but that is not going to happen now. Frutigen has 6700 inhabitants and sometimes it looks as if we have 6700 water engineers (Bircher, 2018)." This shows that the direct democracy in Switzerland can be troublesome if different causes coincide. If the local people do not want change, then change will not come. This problem cannot be described more appropriately than mister Stoffel of the OIK describes it: "Frutigen is quite a special case. Frutigen does not have a water board and is from our point of view the municipality which needs a water board the most. Because there with the Engstligen and the Kander they have big problems. They have had a lot of problems with floods. Then the municipality says we need to do something and the people say, yes but not like this. Then decide to first renew the schoolhouse or whatever and then nothing happens. The opponents come to the municipal voting and just vote against the proposal. Those are the costs of the Swiss democracy. Frutigen is very special in the fact that they have had so many wet feet, but still there is no

action. Not even after 2005. In this valley people are also very conservative so they would rather keep things the way they did it fifty years ago. They do not want to start new projects (2018)." Frutigen is in a very difficult situation and change is urgently required. The analysis of the renaturalisation feature showed the same problem (see section 6.2). Luckily Frutigen is the only municipality that faces this problem and can be considered a bad exemption. There seems to be a major discrepancy between the sense of urgency that has led many local flood risk management practitioners to vouch for drastic measures and the disinterested attitude of the local people in Frutigen. The direct democracy in Switzerland turns out to be a complexifying factor in the case of the municipality of Frutigen. Apparently, the system of a direct democracy only works if you allow the people a limited number of subjects to vote on. Given the option to choose between a schoolhouse and a structural flood measure that is only to be used once every hundred years, the disinterested attitude towards flood measures does not seem far-fetched at all anymore.

Although almost all of the municipalities have done all they could do to learn from the events of 2005 and 2011, the local flood risk management practitioners comprehend that a complete eradication of the flood risks cannot be achieved, however high their efforts may be. Ralf Schai (Lauterbrunnen) summarises this statement, saying: "An event like that in 2005 and 2011 can happen again. I would like to see how our measures would function in such an event, but we are never completely safe in this area. We can do, and we have done whatever we could do, but I always think that tomorrow something bad can happen and that we should be prepared for that. (2018)" Of course this is true, however much the local flood risk management practitioners do to prevent floods and the damage of the floods, some risk will always exist, certainly in a dangerous area like the Bernese Oberland. The lessons that can be learned from the major flood events in the recent past have been drawn however and, in most cases, these lessons have led to appropriate action on a municipal scale. The impact of the major floods of 2005 and 2011 on the local flood risk management practitioners seems exorbitantly bigger than the document analysis suggested, making the lacking attention to these floods in the Gewässerrichtplans even more aberrant and inexplicable.

Interview Evaluation of Lessons Learnt			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
7.) Lessons Learnt (Transformability)	The floods have not been evaluated and similar circumstances would result in similar damage. (Frutigen)	The floods have been evaluated and some action has been taken to lower the impact of a similar event.	The floods have intensively been studied and measures have been taken to prevent flooding in similar circumstances. (All but Frutigen)

Table 26: Interview Evaluation of Lessons Learnt

7.3 Document Analysis of Future Challenges

The extent to which future challenges are taken into account forms an abstract part of the evaluation of the flood resilience of the local FRGA in the Bernese Oberland. Its abstractness does not make it less important, however. Rather it is one of the essential parts of transformability, as it considers the (deep) uncertainty of likely future problems in the current policy plans (Buurman & Babovic, 2016). Climate change for example is likely to impact the local circumstances (BAFU, 2016). This part of the evaluation focusses on how these

challenges are taken into account. The analysis shows large differences between the different parts of the case study area.

The Gewässerrichtplan Kander focusses a lot on the trends that are currently threatening the stability of the local society. The Kanderdurchstich of 1714 still has a major impact on the catchment area of the Kander as erosion causes many structural measures to be dysfunctional (see figure 10) (Summermatter, 2012). This already visible trend is named in the document as one of the main reasons to write the document, and thereby to restructure the river situation (OIK I, 2013b). The following short excerpt shows how the document uses this historical event as a key motivation: "The daring and visionary idea of the time brought about tremendous changes for the Kander and their bed load balance and still has hydrological effects (OIK I, 2013b; p. 1)"

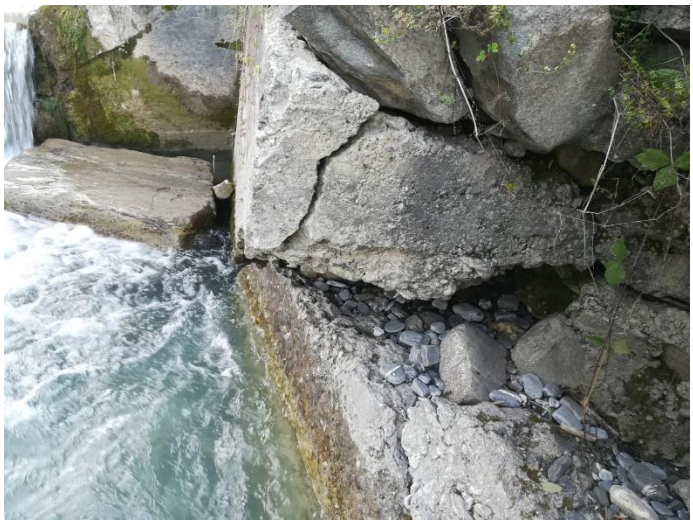

Figure 10: The Effects of Erosion to a Structural Measure near Frutigen (Own Observation, 14-09-2019)

The other main reason to write the Gewässerrichtplan Kander is the changed water laws from 1989, which ask for a more natural management of the rivers. This change in the cantonal water law is referred to as: "The changed philosophy of water engineering set ambitious goals. On the one hand, the waters are of course to preserve or close to nature, on the other hand, serious dangers that emanate from the waters to fend off." (OIK I, 2013b; p.1). Needless to say, a lot has changed in the vision on proper water (flood risk) management in the last 30 years, as the introduction and the theory have pointed out.

To sum up, the motivation for writing the Gewässerrichtplan Kander consists of a 25-year-old change of cantonal law, in combination with a visible trend of erosion caused by a 300-year-old structural measure. In itself these reasons to revise the current situation of river management are not erroneous, but they appear incomplete, given the global changes that affect the local fluvial circumstances. Especially the evidently changing climatic circumstances in the area seem essential for a thorough revision of the river structure (Buurman & Babovic, 2016). It is therefore surprising that these climatic changes, and their consequences such as permafrost melting and more frequent inclemency of weather, do not receive any attention in the vast documentation. This lacking antecedent for the formation of the document is discernible in its ramification, as no direct mention is being made of the changing circumstances whatsoever. Implied references to changing circumstances, such as the focus on 'sustainable' flood management cannot be considered satisfactory (OIK I, 2013b; p.3). The uncertainty that comes along with the (climatic) trends and that almost certainly forms challenges for future flood risk management in the area, must be considered as not being adequately taken into consideration in the Gewässerrichtplan Kander.

Contrarily, the Gewässerrichtplan Hasli-Aare directly names changing climatic circumstances as one of the main reasons to look into a restructuring of the local flood risk management situation (OIK I, 2013a). Within

the 'lead motive' of the document is stated that: "The requirements of modern, risk-based flood protection, as well as the changed conditions regarding discharges and sediment transport (climate change) have to be considered. (p. 32)" This citation not only shows that the changing (climatic) circumstances are taken into consideration in this document. Its pivotal position also shows the priority of this aspect into the whole of the document. Future challenges are mainly taken into account in the structural measures section of the document, such as in the phrase: "Due to changing hydrological and climatic boundary conditions - but also due to increased protection needs - the relevant dimensioning water quantities are significantly higher than before (p.29)." These transparent citations on the role of the uncertainty of certain trends place structural measures, such as those described on pages 78 and 89, in a more complete context. Even though the exact impact of these future challenges is not, and cannot be, described the mentioning of the consideration already indicates a more holistic understanding of the situation.

Future challenges take an even more primal role in overarching documents such as the 'Achtung Naturgefahr' document. This document shows an exemplary look on future challenges, as it notes that: "renewal projects must be designed in the future in such a way that they can be adapted to new conditions with relatively little effort (for example due to higher seasonal outflows or increased solids transport) (AG NAGEF, 2013; p. 28)." On top of this, the 'Achtung Naturgefahr' document neatly describes the possible scenarios that the future might entail (p. 38). This is exactly how the theory dictates flood risk management practitioners ought to look at future challenges. Comparing the local documents to this, the attention on future challenges in the Hasli-Aare document is somewhat meagre, and the lack of attention in the Kander document is alarming (OIK I, 2013a; OIK I, 2013b).

Document Evaluation of Future Challenges			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
8.) Future Challenges (Transformability)	The local decision-makers are unaware of potential future challenges.	The local decision-makers are aware of the existence of potential future challenges, but little action is taken to fight these challenges.	The local decision-makers are aware of the existence of potential future challenges and have taken action to prevent potential problems.

Table 27: Document Evaluation of Future Challenges

7.4 Interview Analysis of Future Challenges

The allocation of time and effort to future challenges is a difficult and uncertain part of the task of the local decision makers. Therefore, much focus was put in the interviews on this aspect of the transformability of the FRGA. The question "what future challenges do you think the area will encounter in the future?" started the inquiry on future challenges. This question focusses on the awareness of future challenges. A direct extension on this question followed: "how are these challenges taken into account in the current policy?" to clarify the answer to the first question and to make sure the future challenges are tackled in practice. The uncertainty that is an inherent part of future challenges has then come to light through the question: "how does the local policy leave room for changes that future challenges may require?" Together these three questions give an

insight into the focus on future challenges of the local flood risk management practitioners, but the abstractness of this aspect cannot fully be eliminated.

The main future challenge that has been articulated by many of the interviewees is climate change. The growing economic viability (see chapter 1) of the area is not considered as a problem by the local flood risk management practitioners, as it is generally a positive trend for the local people. The area does not seem to encounter much economic growth however, which eliminates that part of the equation of increasing flood risk.

Climate change is a very broad and uncertain aspect that has to be taken into account during the formation of FRM policy. As explained in the introduction of this study, the exact implications of climate change cannot be predicted as it is a very uncertain global phenomenon, that has different consequences for every part of the world. This uncertainty leaves the local flood risk management practitioners open to their own interpretation of the trends that are visible in the area. Oliver Hitz (OIK I, Lütschine) summarises the challenges that are caused by climate change as: "There are two major challenges. Firstly, there is the entire climate regime that changes. This can cause the permafrost to defrost, the rain that intensifies, the materials to come down etc. The second major challenge is the retreating glaciers that can cause glacier lakes, create extra sources of materials and that no longer form a barrier for the water to flow down (2018)." Some problems with these challenges occur. Firstly, the uncertainty evolving around climate change makes it hard to predict how these challenges function in this specific climate. Secondly, the impact of these natural phenomena varies between the different areas within the case study area.

Both these problems are recognised by the local flood risk management practitioners. The first point, the uncertainty about climate change as a whole, results in differing views between the local flood risk management practitioners. Some of the local flood risk management practitioners, like the previous citation of Oliver Hitz shows, are very concerned about the future challenges that climate change brings (2018). More examples exist, like Ralf Schai: "Both the amount of water will rise because we will see more heavy rainfall, but also the melting of the permafrost causes more material to come down. Both problems can be problematic for our village as we are very high up in the mountains (2018)." Others are more hesitant to ascribe these challenges to climate change. "We have certain measurements of the last decades that can give multiple interpretations. It is difficult to say. We can see that since 1987 more big flood events have taken place in the area (Kimmerle (OIK I, Kander), 2018)."

The second problem with the challenges caused by climate change is that the consequences of climate change can be very local. The local flood risk management practitioners realise that differences will occur between the different municipalities. Some problems that can be ascribed to climate change will only impact the upstream municipalities whereas others impact the lower municipalities. The previous citation by Ralf Schai shows that the municipality of Lauterbrunnen, which is close to multiple glaciers and can be harmed by

glacier lakes and materials coming down with the streams (see figure 11). Urs Weibel (Kandersteg) supports this claim: "Currently a research project into permafrost has been started on the Doldenhorn near Kandersteg. That study will show to what extent extra material (rocks etc.) will come down with the water. This material can fill the riverbeds and cause floods (2018)."

Figure 11: A Material Extraction Site between the villages of Adelboden and Frutigen (Own Observation 13-09-2019)

Waterboards of the lower municipalities like Lütschental and Bödeli Süd do not consider growing amounts of materials to be problematic for them: "Uhm, here on the one side we have the Männlichen so no permafrost, and the other side is also okay. I don`t think that is a problem. Only maybe something comes from Wilderswil but there is nothing we can do in that case (Teuscher (Lütschental), 2018)." The local expert from the Bödeli Süd waterboard even claims the problem to be less materials rather than more: "Since I joined the Waterboard, we have taken materials out of the river maybe three times. Most of the times the river does this all by itself, however (...) In the delta of the Brienzersee, the materials are taken out anyways. They can take out 45.000 m3 per year of materials. They don`t reach this in the last years, however. The amount of materials is lower. Nature gives us less materials here the last couple of years (Matthias, 2018). The dubiousness of the recorded progression and per extension the disputability of future developments make future challenges very hard to implement.

In spite of the deviating perspectives on the extent and consequences of climate change, the challenges that these perspectives lead to are claimed to be dealt with. Kimmerle for example states: "Well it is clear, also from the gewässerrichtplan that there are certain actions that need to be taken. Some of them have to do with climate change, some have to do with our historical path. These actions are not simply done in one year, some might take decades. But we are on the right track now (2018)." Fahrni agrees with this statement by declaring: "So far as we can see them now, yes (the future challenges have been dealt with), but we work with nature, so we can never be sure. But there have been different studies to show the biggest problems. The biggest problems are far in nature, so they do not form too big problems for society (2018)." It seems therefore that the biggest future challenges are being dealt with. Most of these challenges have to do with another category that is a part of these studies. Some local flood risk management practitioners named these other aspects as the main future challenge within their region. Many aspects have come up, such as: "On the short term the biggest challenge for us is to get the acceptance of the local people to start with the necessary projects (Bircher (Frutigen), 2018)." Although these are important future challenges, they will not be named here, as they are already mentioned in their respective paragraph.

The future challenges that have to be dealt with are hard to predict, because of their inherent uncertainty. On top of that the impact of the eventual future trends differs between the municipalities that are a part of this study. The local flood risk management practitioners do seem to grasp the urgency of the possible impact these trends could have. The future challenges, that do not yet harm the local society, are already taken into account in the everyday decisions of the local flood risk management practitioners. The local flood risk

management practitioners thereby put much more emphasis on future challenges than the document analysis, or at least that of the Gewässerrichtplans would suggest, which is not surprising given the evidence they see every day in the form of a changing landscape and less snow-capped mountains surrounding them.

Interview Evaluation of Future Challenges			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
8.) Future Challenges (Transformability)	The local decision-makers are unaware of potential future challenges.	The local decision-makers are aware of the existence of potential future challenges, but little action is taken to fight these challenges.	The local decision-makers are aware of the existence of potential future challenges and have taken action to prevent potential problems.

Table 28: Interview Evaluation of Future Challenges

7.5 Document Analysis of Experimentation

Future challenges are clearly linked to the need for experimentation. The following quote from the cantonal document on natural hazards, the 'Achtung Naturgefahren', shows this connection: "Many of the smaller works erected in the mid-twentieth century also need to be redone and adapted to today's requirements. (...) The need for renewal is therefore very high, especially in hydraulic engineering. In the course of this ongoing work, the consequences of climate change must not be overlooked. (AG NAGEF, 2013; p. 28)". The paragraphs on future challenges have shown that the focus on future challenges is very limited in the local documentation. On the level of the Gewässerrichtplans, the same conclusion can be drawn. Within the Gewässerrichtplan Kander, no mentioning of experimentation or innovation is made. Some projects might involve some implied experimental designs, and as every flood risk management project is unique, every project is, to a certain extent, inherently experimental. On the other hand, no explicit claim has been made that would suggest any serious experimentation or innovation. The Gewässerrichtplan Hasli-Aare does not outperform its Kander counterpart on this aspect. It only cites a document with an experimental solution to the ecological problems of the local fauna (OIK, 2013a; p.20). It does not require any leap to conclude that this does not compare to the earlier statement of the cantonal 'Achtung Naturgefahren'. On the level of the Gewässerrichtplans, the aspect of experimentation is hardly stimulated.

On an even more local scale, a form of stimulation of experimentation can be found, however. The plans for every individual structural flood risk measure include a variant study. This variant study compares different solutions to the same problem, comparing them on the criteria flood protection, ecology, behaviour in case of overload, maintenance, investment costs, cost-effectiveness and impact on the landscape (Oberingenieurkreis I, 2018; p. 18). These variant studies force the local flood risk practitioners to at least consider a more innovative approach to their case. Looking into local projects shows that this is indeed the case. The local problems in the municipality of Reichenbach (Kander) for example can be tackled in six different ways, of which variant three proves the most efficient option, even though this is certainly not the most straightforward solution, including fish ramps and extra space for the river. Similarly, in the case of the village of Frutigen, six variants have been considered, of which an innovative solution including a dead wood

retainer proved the most effective (OIK 1, 2015; p. 23-25). Model experiments of this experimental solution turned out to be too costly, however. In the end, a less experimental solution is the final proposal to solve the local problems in the case of the village of Frutigen. This does not undo the fact that the effort to consider such an experimental design is progressive. As every measure has a variant study comparable to the ones previously mentioned, experimentation is considerably stimulated in the case study area after all, be it on a very local scale.

Document Evaluation of Experimentation			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**
9.) Experimentation (Transformability)	There is no room for innovation and experimentation in the FRGA.	Innovation and experimentation can be considered in the decision-making process.	Innovation and experimentation are actively stimulated to find new and better solutions to local problems.

Table 29: Document Evaluation of Experimentation

7.6 Interview Analysis of Experimentation

Contrary to the other two criteria of the transformability dimension, the experimentation aspect is a rather tangible criterion. The existence and implementation of innovative solutions and experimental measures can straightforwardly be confirmed. The question "how does the local policy encourage experimenting/ innovative projects?" invokes an explanation on the extent of experimentation within the FRGA.

The most innovative large-scale experimental project within the case study area is within the area of the Bödeli Süd waterboard. Oliver Hitz (OIK I, Lütschine) explains why this area is so innovative: "The project on the Bödeli is very special of course. We try to reach a very high defence potential. Even above HQ300 will be reached. The potential damage is very high in this area, so we have to do something. On top of that we have done some studies into the changing circumstances in the Lütschine. Floods seem to become more frequent and heavier especially in this area. The system is changing and where it is heading, we do not know. Therefore, we decided to reach for very ambitious goals to ensure the safety of a large part of the Bödeli. That means the defence goals are very high in the area (2018)." This lengthy and clear quote shows that experimentation becomes an option when the urgency is high. In the Bödeli area, the urgency originates from the high economic value of the area.

The experimental nature of the project by the waterboard of Bödeli Süd are explained by the local expert as: "The biggest project we have is the Hochwasserschutzplan Bödeli. That is mainly about the Lütschine. We cannot change the course of the river because of all the buildings and cables in the ground etc. Giving the river more space is therefore no option below Wilderswil. We therefore built some dams, for example in Bönigen. On top of that we are going to make two different exits for the water. The water will be flowing over the former airport to the Brienzersee. So we have certain bridges that cannot handle extreme water amounts, so before those bridges we have made options to let the water flow over the land. The one in Gsteig will flow through the soon-to build- tunnel towards the Brienzersee. The other one will flow over the former airport and the highway. That is quite special, to be allowed to flood a highway, but there is no other

option (Matthias, 2018)." The height of the economic value is the reason for the high (HQ300) robustness standard. The impossibility of the 'normal' structural measures requires the experimental ideas that have been used in this area. Other circumstances help to facilitate these innovative projects. As the economic value of the area is very high, the financial options of the waterboard are also high, because of the way the budget of the waterboard is a percentage of the value of the vulnerable properties (see §6.3 and §6.4). The waterboard of Bödeli Süd also has a lot of vigour and expertise because it stretches out over multiple municipalities (Matthias, 2018). The circumstances in the Bödeli Süd area enable the local waterboard to think outside-the-box, leading to the probational and exhilarating plans described above.

Other municipalities also have innovative plans. In the Hasli-Aare area, a lot of effort is put into saving the fish species that live in the Aare (Banholzer, 2018). Not all municipalities can focus on innovation, however. Innovation requires budget, which is not available in smaller municipalities with lower economic value to protect. An example of this is the municipality of Lütschental (Teuscher, 2018). A waterboard like the Bödeli Süd waterboard, in which multiple municipalities are represented can perform better on criteria like experimentation. As the local expert sees a lot of benefits for such an organisational change and this structure shows its viability on the experimentation criterion and on multiple other criteria (structural measures etc.), such a cooperation seems recommendable. The smallest villages (like Saxeten in the case of Bödeli Süd) within such a cooperation might suffer from such a cooperation, however, as their interests become subordinate to those of the larger villages.

Innovation is important to improve the flood resilience on a longer time frame. Some local flood risk management practitioners do not see any option to do so, however. Mister Weibel (Kandersteg) for example states: "Experimentation on flood risk management measures is not a good idea as we simply do not have the means and it is not economically viable. Of course we do look at the different options we have, but we cannot experiment (2018)." Ronald Kimmerle (OIK) seems to contradict the local expert by stating that Kandersteg does have an experimental solution to the flood threat: "Yes. We always do the variant studies. Sometimes an experimental plan seems the best plan. For example, in Kandersteg there is a very strict corner where the water has to take a bend. The new project was to put rocks in that bend. That is a very unconventional idea, but it turns out to work exactly how we want it to (2018)." The exact definition of 'experimental projects' turns out to be ambiguous, but the project in Kandersteg has not been executed before and can therefore be considered experimental. The variant studies that have been considered in the document analysis already are the main supportive tool to promote experimentation. The ambiguousness of the variant studies as a part of experimentation apparently also divides the local flood risk management practitioners.

Experimentation and the search for innovative solutions to the local flood risk is established in some of the local communities. Some progressive projects help to prevent floods or flood damage and can help other areas to find a fitting solution to their local problems. Not all municipalities have the ability or the incentive to focus on innovative solutions, as mostly the financial means are lacking in smaller communities. This is not directly life-threatening, but it is not the desired state of flood resilience and it therefore requires improvement, which can be attained by a more exhaustive cooperation between municipalities.

Interview Evaluation of Experimentation			
Evaluation Criteria	**Insufficient**	**Advancing**	**Good**

9.) Experimentation (Transformability)	There is no room for innovation and experimentation in the FRGA.	Innovation and experimentation can be considered in the decision-making process. (All but Bödeli Süd)	Innovation and experimentation are actively stimulated to find new and better solutions to local problems. (Bödeli Süd)

Table 10: Interview Evaluation of Experimentation

Chapter 8: Conclusions

The eighth chapter of this research forms the overarching conclusions. The entire research is brought together in this chapter to analyse what has come forth and to conclude what this means. The research questions are answered in this chapter. Firstly the individual sub-questions will be answered, to complete the research and formulate a final answer on the main research question.

8.1 Conclusions on Robustness

The first sub-question that will be answered is: `To what extent is *robustness* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`. The Introduction (chapter 1) has shown that robustness is the traditional form of flood management. It aims to lower the flood risk by preventing floods from occurring. The theory specified multiple ways to enhance robustness. These can be divided into two categories: structural measures and spatial measures. Documents have been analysed to see whether these two categories are being promoted by the local FRGA in the Bernese Oberland. The local experts from the Oberingenieurskreis and the local municipalities have also been asked on their insights on these measures. Several conclusions can be drawn from these forms of data.

Structural measures are still very important and form the basis of the GRP documents. They include very detailed descriptions of the safety level deficits that are to be overcome and the projects that are necessary to overcome these deficits. Every village is required by the canton of Bern to at least reach an 'HQ100'-safety level, whereas less valuable areas only require an HQ30 level. The GRPs describe where these safety levels are not yet reached and which projects are necessary to reach this. These projects are then to be executed by the municipalities/water boards. The Lütschine area, that does not have a GRP yet has to comply to the same standards as the rest of the case study area, but the more rural parts of this area seem less incentivised to do so. The other two catchment areas show very clear documentation on which structural measures are to be implemented and how to do so. It seems only a matter of time before the entire region reaches the standards that have been set by the cantonal government.

The local flood risk management practitioners also consider structural measures to be very important. The interviews have shown that most of their attention goes to the enhancement of this aspect of flood resilience. The level of protection is very important to the local people, to make them feel safe. Most of the villages have therefore worked very hard to reach the required level of safety. Some examples, like the villages in the Bödeli Süd and the village of Lauterbrunnen will even surpass their required safety levels, going beyond the goals of the document analysis. The only, rather alarming, exception that has come to light through the interviews is the village of Frutigen, where the safety levels are still substandard, and the plans cannot be executed due to unwillingness of the local population. This is a very serious situation that originates in the local organisational structure in this municipality. The lack of a water board brings about a situation in which the budget for flood management has to compete with other local goals, dramatically restraining the implementation of the GRP. This situation urgently needs to change, as the local people are not safe.

The second category of robustness measures that has been derived from the theory is 'spatial measures'. Spatial measures in the case study area, are based on the danger maps. These maps show which areas are most exposed to floods. The maps are very detailed and exist for most but not all of the case study. Within these

most exposed areas (red zones), no new constructions are permitted to be built. Within less exposed areas (blue zones), special requirements have to be met for new buildings to be permitted. These special requirements can impose local protection measures on the private individuals, stimulating adaptability as well. The GRPs make some mention of projects where the water is given extra space. These areas often do not contain any properties and therefore are not to be considered impacting spatial measures. The buildings that are already within exposed areas are not forced to relocate, forming a loophole in the spatial measures policy and limiting its functionality.

The danger maps that form the basis of the spatial measures are very important to the local flood risk management practitioners. According to their inside perception, the danger maps function splendidly. They claim to be involved only sidewise in the formation process of these plans, which is suboptimal, as they have a valuable contribution to make, since they know most about the local situation. Some examples of vulnerable properties within the most exposed areas have come forth and no effort is put into their relocation.

All in all, the robustness dimension of flood resilience is stimulated aptly through both structural and spatial measures. The cantonal governments requirements of safety levels are actively being strived for. It will only take time for these goals to be reached or even surpassed in all parts of the Bernese Oberland, with the striking exception of the village of Frutigen. The danger maps form a solid foundation for the spatial measures, which consist mostly of constraints on building in vulnerable areas. Properties that are already within vulnerable areas are not forced or incentivised to relocate, leaving room for improvement.

8.2 Conclusions on Adaptability

The second dimension of flood resilience that was derived from the theory is called 'adaptability'. Adaptability is enhanced when the damage of floods that cannot be prevented, is limited. This part of the analysis tried to answer the sub-question: `To what extent is *adaptability* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`.

The first criterion of adaptability, that has gotten limited attention in the scholarly literature on the subject is renaturalisation. It focusses on the sustaining or return of the original ecosystems. Renaturalisation is one of the main objectives of the GRPs. In both the Kander and the Hasli-Aare goalsetting, flora and fauna have a primary role. All projects are to take the ecological needs of the river ecosystem into account. In this manner no project can do any harm to the condition of the ecosystems. On top of that, many renaturalisation plans have been set out in the case study area.

The local flood risk management practitioners, however, are much less keen on renaturalisation projects. Not many projects are planned for the sole purpose of ecological betterment. The main reasons for local flood risk management practitioners to execute renaturalisation plans are that these projects are well subsidised by the cantonal government and that they can be a part of some other project that needs to be compensated. The importance of renaturalisation has not dawned on the local experts and per extension by the local people. The realisation of its urgency has to dawn on the local people if the projected plans are to be implemented.

The second feature of the adaptability dimension has to do with the societal ability to recover after a flood. Insurance is not a part of the GRPs, nor the responsibility of the interviewees. It is, however, obligatory for all private property owners to have a building insurance. The costs of these insurances depend on the building

materials and the exposure to natural hazards, incentivising local protection measures and relocation. The fact that every building is privately insured and that the canton or, if need be, the federal state backs the insurance companies up is very positive.

The local flood risk management practitioners do not have much knowledge of the insurance situation, which can negatively impact their advice to the local people. For as far as they are informed the insurance situation is functioning well, but this conclusion is not very reliable, as it is not their responsibility and their knowledge on the subject is lacking (see section 9.3).

The third way to lower the damage of floods that was derived from the theory is through evacuation plans. Evacuation plans are not public as that could increase the damage of a possible terrorist attack. However, all exposed areas have evacuation plans that have been formed by the municipal organ, the GFO/RFO in cooperation with the local fire department. They also have the responsibility over the sirens, which set the evacuation plans in motion. The availability of the evacuation plans is lacking however, which could easily be changed and be a substantial improvement to this feature of adaptability.

The local experts are convinced the evacuation plans function as they should. They are aware that the plans are regularly practiced, but are not engaged in the formation of the evacuation plans. The site visits have shown that some evacuation plans are publicly available, partly resolving the lacking availability online. Water level measurement devices have also been spotted and can be accessed online to inform the local people on their present danger level.

Local protection is hard to find in the documentation, as it is mostly a private endeavour. It is required by the cantonal government however, stating: "If a spatial planning solution is not available, the risk of new or modified hazardous areas must be minimized by means of object specific safety measures. (Kanton Bern, 2019)". The 'Achtung Naturgefahren' document gives a very clear description of what local protection are possible in the case study area. The more local documentation such as the GRPs and local project documents do not make reference to any local protection measures.

The municipal experts have little knowledge about local protection measures. Local protection is encouraged by the OIK I, who give out the permits for new constructions in the blue zones (the moderately exposed zones) and thereby have the power to force new buildings to include local protection measures. Local protection measures are stimulated by the insurance companies and by the OIK, but not many interviewees are aware of that, which makes the functioning of this stimulation disputable.

In conclusion, not all features of adaptability are actively stimulated by the local FRGA. Renaturalisation is stimulated by the higher levels of governance, but that does not seem to have the intended effect on the local experts and people. Insurance is available and has proven to work aptly, although the knowledge of the local experts on this matter is limited. Evacuation plans exist and have been practiced, to make people aware of their functioning. The availability of the plans online needs improvement. Local protection measures are hard to evaluate. The OIK actively stimulates these measures, without much contribution from the local experts.

8.3 Conclusions on Transformability

The third and final dimension of flood resilience is called 'transformability'. Although this dimension does not receive as much attention in the international scholarly FRM literature as the other two dimensions, it is important as it deals with the deep uncertainty that is inherent to the nature of flood management. This dimension is analysed by answering the sub-question: `To what extent is *transformability* supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`

The first feature that helps assess the state of the societal transformability of the Bernese Oberland is through the 'lessons learnt' from the floods that have scourged the area in the past. The 2005 floods have intensively been studied on a national level. The GRP of the Hasli-Aare area states that the impact of the floods then, are not allowed to happen again. The GRP Kander does not specifically name any lessons drawn from floods in the (recent) past.

The interview analysis shows that the local people are very much impacted by the floods of the past. This is one of the main reasons for them to go on and change the structure of the rivers. Most of the villages have implemented measures to prevent a flood of the same scale as those in 2005 from having the same impact as they had then. Frutigen forms the same exception as on the structural measures indicator. The fact that serious flooding has not occurred since 2005 means the lessons learnt have had their impact, but it also worries some of the local experts that the risk awareness is going down (Matthias, 2018).

The second indicator that shows the transformability of the local FRGA is 'future challenges'. Future challenges such as the impact of climate change on the local flood risk play no part in the GRP of the Kander. A little more attention is payed to this subject in the GRP of the Hasli-Aare. Still its focus on the subject is limited considering the immensity of the potential threat. The cantonal document 'Achtung Naturgefahren' clearly shows the different future challenges and should be seen as an example of how the local FRGA can take future challenges into account.

The local people care much more about the future challenges than the GRPs suggest. They see the effects of climate change in their livelihoods and are very dedicated to combat them. Problems such as the melting of the glaciers and its effect on the local rivers, are taken seriously by the local experts, although dealing with these problems is difficult given their inherent uncertainty.

The third feature of transformability is experimentation. Innovative and experimental solutions can help improve the local FRGA by finding solutions that are specifically designed for the local problems. Sadly, experimentation does not play any role in the GRP documents. On an even more local scale, some experimentation can be observed, as local projects require a variant study which can be considered as stimulating 'experimentation'.

The local flood risk management practitioners do not see much chance to experiment, because of their limited budget. Larger water boards, such as Bödeli Süd have some very innovative projects, but the smaller water boards do not have this chance. The variant studies are considered by some as an aspect of the local FRGA that stimulates experimentation, whereas others do not recognise it as such.

All in all the attention for the third dimension of flood resilience is rather limited. The features lessons learnt, future challenges and experimentation hardly get any attention in the GRPs. Experimentation is only stimulated on an individual project level, without stimulation from higher levels of governance. Luckily, the local flood risk management practitioners are aware of the lessons that are to be learned from the major floods of 2005 and 2011. They are also conscious of the challenges the future holds for the local communities, as they can see the consequences already. Experimentation is considered differently by each of the individual local experts. The Bödeli Süd projects are very innovative and can be regarded exemplary for the rest of the case study, which is only limitedly stimulated to innovate through the mandatory variant studies.

8.4 Conclusions on the Flood Resilience of the Bernese Oberland

All three sub-questions of the research have now been answered. Together these answers form an elaborate summary of the findings of this research. It is now time to turn to the main research question: `What dimensions of flood resilience are supported or constrained by the local FRGA in mountainous river catchments in the Bernese Oberland?`.

The flood resilience dimension of robustness is adequately supported by the local FRGA by safety level guidelines from the cantonal government, clear documentation on structural measures that are to be implemented in the near future and danger maps that meticulously describe where economic development can take place and which areas are too exposed to be used for construction purposes. Measures that enhance robustness seem to be the go-to response, because of path-dependency and an ideal of complete safety.

Some factors still constrain the robustness of the local FRGA. The most notable is the lacking safety level in the village of Frutigen, where the local people obstruct the necessary structural measures. The main reason for this obstruction is the lack of organisational clarity, because of the absence of a local water board. This situation leaves the FRM in competition with other, more palpable municipal projects. Another constraining factor is the unwillingness to relocate vulnerable properties that are already within exposed areas. Despite these two constraining factors, the local FRGA in the Bernese Oberland focusses a lot on structural and spatial measures to ensure the stability of the local society, and must be therefore regarded as robustness.

The flood resilience dimension of adaptability is only limitedly supported by the local FRGA. Renaturalisation is actively stimulated by the higher levels of governance but its importance is yet to dawn on the local experts and per extension to the local people in the Bernese Oberland. A large constraint on the implementation of renaturalisation stems from the absence of a GRP in the Lütschine area, which is urgently required, not solely for renaturalisation, but for multiple other aspects of flood resilience. Similar conclusions can be drawn on the analyses of the other criteria for adaptability. The higher levels of governance seem to adequately support insurance, evacuation plans and local protection. The insurance situation has proven to be functional and healthy. Evacuation plans exist and are being practiced and the danger maps clearly set out where local protection measures are required. The local experts, and more so, the local people do not participate in the formation of these plans, which leaves them uninformed and thereby severely constrains the adaptability of the local FRGA.

The flood resilience dimension of transformability is crudely supported by the local FRGA. Little attention is paid, in the (GRP) documentation to the lessons learnt and future challenges criteria. The local experts do not

seem to need any stimulation to focus on these aspects, as they are well aware of the urgency of these aspects of transformability. The lessons learned from previous floods and the future challenges that are imposed on the local FRM practitioners are thereby taken into account adequately on a local level. The opposite must be concluded on the experimentation criterion, as this is regarded by the local experts as an additional, nonessential option to increase the flood resilience of the local FRGA. Only the bigger water boards, with a higher budget, feel the need to earnestly look at this option.

All in all, the flood resilience dimension of Robustness is adequately stimulated by the local FRGA in the Bernese Oberland. A focus on the adaptability dimension can certainly be observed, but adaptability is constrained by the lacking involvement and sense of urgency of the local experts. The focus on the transformability dimension of the local FRGA is suboptimal and requires more support, mostly from the higher levels of governance.

Chapter 9: Discussion

9.1 Interpretation of the Findings

This research has shown interesting insights into the functioning of the local FRGA. Some of these insights can be very helpful for the local FRM practitioners. The research has shown that the local FRGA in the Bernese Oberland focusses a lot on the enhancement of robustness, with a rather limited focus on adaptability and transformability aspects.

The research has also found that water boards have big advantages over municipal governance for the local FRGA, as it specifies a certain budget to the betterment of local flood resilience and it can bring expertise on the subject together. Relatedly, the research has found that direct democracy can hinder local FRM projects, if no water board is in place. If local people are allowed to vote on municipal budget, more palpable options often take precedence over FRM policy.

The influence of the mountainous circumstances is clearly visible in the array of possible solutions to the local problems. Retaining areas for example, are frequently used in the case study area, whereas its application had not been found in the international scholarly literature. The mountainous circumstances also stress the urgency of the challenge imposed by climate change as its consequences are clearly visible to the local people.

Some aspects of the FRGA in the Bernese Oberland are exemplary for other areas. The deficiencies of the structural measures and the exposure to natural hazards is well documented in the danger maps. These danger maps form the basis for a lot of measures, by showing where (local) structural measures, as well as evacuation plans and other adaptability measures are necessary.

Other aspects of the FRGA in the Bernese Oberland require more attention. The impossibility of the complete eradication of flood risk has not dawned on all of the local experts. This makes them unaware of the importance of certain adaptability and transformability aspects and could potentially destabilise the local society in case of extreme flood events. Similarly, the urgency of a rising flood risk has not resulted in a completely holistic focus on all possible measures. For example, the relocation of vulnerable properties, such as campsites from the most vulnerable areas, is not enforced, nor actively stimulated.

9.2 Implications of the Findings

The results of this Master's thesis have important implications for the local FRM practitioners as well as for the international scholarly community. The research has improved the understanding of cooperation and functioning of local FRM in the Bernese Oberland. It has shown what the strengths of the FRGA in the Bernese Oberland are. These strengths, such as the structural measures and the functioning of the danger maps show what the FRM policy has achieved over the years. It also shows the parts of the case study that are not yet using these strengths to their full potential, how to do so in the future.

The research also shows the weaknesses of the FRGA in the Bernese Oberland. These weaknesses, such as the limited focus on both adaptability and transformability have been analysed and described in detail. These

weaknesses constrain the flood resilience of the local society and are to be overcome by changes in the FRGA to ensure the safety and the stability of the local society. The interviewees of this research are the exact people with the ability to make the required changes in order to keep their homes safe in the future.

Holistic FRM is a rather new trend. The theoretical section of this thesis describes and compares different theories on FRM to create a useful evaluative framework for this research. This theoretical comparison allows academics to see the different measures that enhance flood resilience and their respective position in the individual theories. The inclusion of deep uncertainty theory into the transformability dimension of flood resilience theory can help the academics of the compared framework create a more complete understanding of flood resilience.

Academics can also benefit from the elaborate analysis of the functioning of the FRGA in an isolated mountainous area. It allows the international scholarly community insights into the impact of certain circumstances to the implementation of FRM policy. Important insights for academic readers include the measures that are specific to the mountainous context such as retaining areas. Another important academic finding is the constraining effect of the direct and decentralised democracy on the implementation of flood resilience policy. The most important academic finding of this research, however, is the technocratic focus of the FRGA. This focus on structural measures constrains the adaptability and transformability of the local society, and requires a large (discursive) change to make the FRGA more flood resilient.

9.3 Limitations of the Findings

This Master's thesis describes a local situation of a specific academic field, restricting its implications as described in the methodology. Its interpretivist epistemology dictates that the implications of the findings of this research are valid, but limit its generalisability. The 'snapshot' character of this research entails that similar research done at a different time and place and therefore probably with different interviewees or interviewees with a different understanding of reality would reach different conclusions. This is consistent with the 'process' nature of the policy field. A policy is not an absolute state, but a process towards a certain goal, and it is therefore different in a different time and space.

The findings are limited to the contemporary state of the local FRGA in the Bernese Oberland. The validity of the findings is believed to be solid as the research has used multiple documents from different (governmental) sources, based on exploratory talks with experts from the University of Bern in combination with several long semi-structured interviews and site-visits. The interviews cover the entire population of OIK-level experts of the case study. These experts are full-time professionals in the local implementation of FRM policy. The interviews also cover the responsible local experts of about half the municipalities in the case study. The OIK- professionals and the municipal experts are the responsible agents when it comes to FRM policy. The decisions they, together, make on the FRGA is implemented with the approval of the local citizens. Together with the documents and the site visits, the interviews are therefore believed to create a complete view of the current FRM policy in the Bernese Oberland.

The research has concluded that the participation of the interviewees (both cantonal and municipal) on the policy implementation of the criteria insurance and evacuation plans is limited. The information provided by the interviewees on these subjects is therefore secondary. The site visits have shown evacuation plans and local people have ensured their awareness on the subject. These site visits do not provide much information

on insurance policy, however. The conclusions on these two criteria are thereby mostly based on the documents as primary information, and cannot be considered conclusive proof for the functioning of these two elements of adaptability.

9.4 Recommendations for Further Action and Research

The limitations of this thesis have shown that the scope of this research is local (the Bernese Oberland) and field specific (FRM). This leaves room for a broadening of the scope of the research. Future research could look at mountainous areas in a broader sense, looking at Switzerland on a national level, or even the entire alpine region together. A focus on Switzerland would allow the research to be compared one-on-one to the results of the nation reports of the STAR-FLOOD research (Hegger et al., 2016).

A broader scope of this research would also allow the possibility of involving more stakeholders into the research. A first important step towards a broader scope would be to involve the GFO/RFO, fire department and citizen stakeholders into the research. This would increase the validity of the findings on the aspects of insurance and evacuation plans.

Another option for further research is to increase the scope of the research to focus on all forms of natural hazards. Mountainous areas are scourged by mud streams, storms and avalanches, which require different solutions. The budget of natural hazard management has to be spread out over these different forms of natural hazard management, which is a very interesting topic of research. Who knows, one day I will be able to investigate it myself.

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Appendix 1: Deriving the Criteria from the Theory

Location of the Criteria in the Theoretical Framework			
Flood Resilience	**Flood probability reduction**	**Flood vulnerability reduction**	**Adaptive capacity (of society)**
As conceptualised by Restemeyer, Woltjer & van den Brink (2015)	Robustness	Adaptability	Transformability
As conceptualised by Hegger et al. (2016)	The prevention strategy & The defence strategy	The mitigation strategy, The preparation strategy & The recovery strategy	Parts of the preparation strategy
Individual resilience measures as brought forth by Alexander et al. (2016)	**Spatial measures** such as: spatial planning policy that prevents further economic development in flood prone areas and multi-functional land use **Structural measures** such as: dams, dikes, embankments and demountable defences	**Flood mitigation measures** such as: flood storage areas, (Re)naturalisation, local protection **Preparation measures** such as: evacuation plans, early-warning systems and informing the public through education and participation **Recovery measures** such as: (re-) insurance and community building	**Enhancing adaptive capacity** by: cultures of institutional learning, knowledge exchange at the scientific-policy interface (experimentation), adaptive management approaches in the delivery of flood defence measures (Lessons Learnt) and forward planning for future risk and climate change (Future Challenges) **Enhancing transformability:** indicate brochures, public campaigns, education, participatory governance tools and consensus building.

Appendix 1: Summary of how the key concepts of flood resilience are related (based on Restemeyer, Woltjer & van den Brink (2015) and Alexander et al. (2016))

Appendix 2: Interview Questions

Introductory Questions

1) Please introduce yourself for the record and explain your role in the local flood risk management policy of the mountainous river valleys in the Bernese Oberland.
2) Can you explain the impact of the last floods in the area in which you work?

Lowering the Probability of Flooding (Robustness)

3) Please give examples of structural measures that lower the *probability* of flooding in the area (in the Kander/Lütschine valley respectively).
3b) To what extent are these measures effectively lowering the *probability* of flooding in the area?
4) Are the spatial planning measures (zoning, Gefahrenkarten etc.) effectively lowering the amount of economic activity in the flood prone areas?
5) What aspects of the FRGA in the area in which you are responsible are in your opinion exemplary for other mountainous areas when it comes to lowering the *chance* of flooding (Strengths)?
6) What do you think are the main challenges for the local FRM strategy when it comes to lowering the *chance* of flooding in your area (weaknesses)?

Lowering the Potential Damage of Flooding (Adaptability)

7) Can you give examples of measures that have been taken to lower the *potential damage* of flooding (evacuation plans/renaturalisation/insurance etc.) in the area?
7b) To what extent are these measures effectively lowering the *potential damage* of flooding in the area?
8) Can you explain how you work together with the local communities (municipalities)?
9) How are the local inhabitants involved to make them aware of the flood risk? (so they can take their own responsibility in lowering the potential damage and so they know how to escape a flood in case of an emergency).
9b) Do you see any flood proof building in the area?
10) What aspects of the FRGA are in your opinion exemplary for other mountainous areas when it comes to lowering the *potential damage* of flooding (strengths)?
11) What do you think is the main challenge for the local FRM strategy when it comes to lowering the *potential damage* of flooding in your area (weaknesses)?

Preparing for Future Challenges (Transformability)

12) What future challenges do you think the area will encounter in the future?
13) How are these challenges taken into account in the current policy?
14) How does the local policy leave room for changes that future challenges may require?
15) How does the local policy encourage experimenting/ innovative projects?
16) To what extent do you think the area is prepared for future flood challenges?

Appendix 3: Transcripts of the interviews

Flood Risk Management in Mountainous Areas

Interview Transcripts with local expert:

Kandertal

1) OIK I
2) Schwellenkorporation Kandersteg
3) Tiefbauamt Frutigen

Lütschinetal

1) OIK I
2) Schwellenkorporation Lütschental
3) Schwellenkorporation Lauterbrunnen
4) Schwellenkorporation Bödeli Süd

Hasli-Aare

1) OIK I & II
2) Schwellenkorporation Innertkirchen

Kandertal Interview Transcripts

Content:

OIK I (Kander): Roland Kimmerle

24-05-2018 in Thun
Interviewer: Steven Daniëls
Language: Hochdeutsch
Short introduction of the research

Could you please introduce yourself and your role in the flood risk management in the Bernese Oberland?

Of course, my name is Roland Kimmerle. My job is similar to that of Oliver Hitz and Damian Stoffel. The big difference is that I am responsible for the Kandertal area. Not just the Kandertal, also around the city of Thun, but my main responsibility is the Kandertal.

I have been to Frutigen and Kandersteg already. Kandersteg has a water board, Frutigen does not. Do the other municipalities in the area have a water board?

Adelboden has a water board. Reichenbach, Wimmis and Kandergrund as well. Aeschi does not.

Does that make a difference to you?

Shortly, yes. A water board can make decisions more quickly. They have a certain amount of money assigned to flood risk management. In the municipalities it is always difficult to divide the money over all its tasks.

Can that be seen as a problem?

I would not speak of a problem. One should simply organise differently. But it is true that the water board can focus better, also in personnel. In a municipality it is often someone from the construction department that does flood risk management as a small part of his job. These projects, depending on the magnitude of the project, can take a lot of time and effort, which can be difficult for a municipality to do. You have to organise it differently then.

An example of this is Frutigen. They have two very big projects at hand. They have a special support group now to help with these projects. They asked a specialised external bureau to help them, to give them the necessary support.

Is that merely of a technical kind?

No, the entire organisational side. For the technical side there is an engineering company, this is merely for the organisational support of the municipality.

Has the Kandertal area recently been hit by floods?

Well of course 2005, but I do not want to go back so far. We have had more recent floods in this area. In 2011 this area has been hit severely again. After the event, we have made an analysis of the event. In this analysis, we can see what kind of processes have caused the flood and what kind of processes have been set in motion. We can now see what the causes were and what we can do about it. It is an analysis focussed on solving the problems. Here I have parts of that analysis *shows documents*. It gives a summary of the event, how the event was managed, what damage was done to the area etc.

So the damage was high in 2011?

Yes, you can find that in the documentation as well. I think it was around 30 million Swiss Francs. It was definitely the biggest of the last years. We had a few middle large events, like in 2014, but the damages were not as big anymore.

Did that have to do with the new measures or were the events simply smaller?

Both. The events were not the same. In 2011, the circumstances were very special. There was a warm wind that melted a lot of snow. On top of that a lot of rain came down. In 2014 the problem was caused by a thunderstorm. That was more local. But the first measures had already been in place as well. For example in Kandersteg a lot of damage was prevented with the new measures.

There is a gewässerrichtplan called `Kander 2050` designed for the area. Why did you make that?
Generally, we do things when the law asks us to do something like this. It is very important to know how the roles are divided. We have the cantonal water law and that tells us who is responsible. It tells us that the municipality is responsible for their own part. Our role is to have the overview.
When we look at the Gewässerrichtplan, we see that there is a need for it, which can be seen in the cantonal water law. It is necessary in catchment areas with a special need for an overview. The Kandertal is one of those catchment areas as there are ten municipalities in the area. This means that measures that are implemented here must be in tune with other measures. Therefore, under our lead a gewässerrichtplan was developed.
First, we made a concept; we showed with expert knowledge what the deficits in the area were. Where can we gain? We also asked the local people for advice. What do they want and need? That all formed the concept plan. In 2009 all of this together formed the gewässerentwicklungsconcept in 2009. The next step was to get rid of the conflicting opinions and problems. Then we tried to get rid of these as good as possible, to finalise the gewässerrichtplan in 2013.
The gewässerrichtplan Kander now shows clearly, where which measures are necessary on which locations. Based on this gewässerrichtplan the municipalities and water boards can plan their own projects. Now we have an annual meeting with all the municipalities and water boards to see what the current situation of all projects is.
On this map we can see that Kandersteg has realised almost all of its projects whereas lower in the valley not much has been done. Was it planned to start on the top or is there some other reason?
It is always the municipality or the water board that gives the exact dates of the projects. They say: "now we do this." We have no say in that. Often there are external circumstances that help the municipality to start such a project however. For example in Kandersteg we saw big floods in 2005 and 2007 which gave them enough incentive to initiate the projects. These projects were almost finished in 2011 and prevented a lot of the damage in the village there.
Is there any prioritisation between all of the naturalisation project that have been planned and the flood risk management measures?
Well, we have to of course take the financial and personnel capacities into account. In the municipalities and water boards, the flood risk management has a bigger priority than the naturalisation measures.
I saw that Adelboden is not a part of the Gewässerrichtplan, why is that?
Correct. At the start of the concept phase we looked into the area. Do we need to look at the entire catchment area or can we leave parts out? There were diverse reasons not to add Adelboden in the plan. The Engstlige between Grassi and Adelboden is a natural park, which we cannot alter. There is hardly any infrastructure in that area. We want it to stay like that. There is no need for water projects there.
Adelboden itself is in a dangerous area however, is it not?
Yes, the Engstlige and Allenbach can do damage to Adelboden. These two rivers have been changed already however. Of course there are still things to do there but the exchange with the Kander is very limited.
What are the main future challenges for the area?
Well it is clear, also from the gewässerrichtplan that there are certain actions that need to be taken. Some of them have to do with climate change, some have to do with our historical path. These actions are not simply done in one year, some might take decades. But we are on the right track now. Almost every municipality is at this moment at least planning to reconstruct the Kander. On top of that there are many smaller rivers on the sides. All in all we are very active on our tasks.
In my opinion the first thing that needs to happen is that in the coming years all of these measures have to be implemented. The other thing is the material management. We have shown how the materials flow and we

also see that there still are some deficits in this regard. We have to make sure that these deficits lower. To make sure the materials can find their way down all the way themselves. Studies are currently being conducted above Kandersteg as to the effects of the melting of permafrost on the materials. We already know what the hot spots of materials are.

When it comes to melting of glaciers and permafrost, it is only focussed on Kandersteg or also a little on the Wildstrubel region above Adelboden?

The hot spot is definitely Kandersteg. That is where the studies are conducted now. Adelboden has a little. Furthermore the Gamchi Glacier above Reichenbach is under permanent supervision as there have been some glacier lake formations there.

I have been to Frutigen, where I spoke with Herr Bircher. He told me there were two big plans there. The plans were not executed however as the people voted against the plans. How do you see this?

That is correct. The two projects, one on the Engstlige, one on the Kander are both very far already. There have been different variant studies. Two choices were made. Now we see not all of the people involved are happy with those options. Now we are in conversation with the people that do not like the plans.

Will the projects still happen then, or can the people say, no we do not want anything?

No, what herr Bircher has also told you I think is that he has initiated an advisory group with the people involved to make sure people understand the plans. That should lead to a solution so both the projects can take place. The municipality has clear that is wants and must implement these two projects.

Is that for now still the weak spot when it comes to flood risk management in the Kandertal?

One can say that in the part of Frutigen certainly the protection deficits are among the highest yes. Kandergrund also has some of these deficits as well.

I have seen that on the Bödeli the protection level is over HQ300, because of the high damage potential. Does that also count for a village like Frutigen?

It is not just the damage potential. We also look at how the situation would change if the measures are completed. How would the Gefahrenkarte look if all of the measures are completed? In the case of Frutigen, an HQ100 is sufficient, if we look at the circumstances. Based on that and a risk analysis we decide the protection levels. When the risks are still too high, extra measures can be taken. Frutigen does not need that. When we reach the HQ100 Frutigen will be protected well enough to reach the cantonal goals. Bödeli is an exception to this.

There are also dangerous side creeks, but they are not in the gewässerrichtplan, what is the reason for this?

No, they are not. Those have been separately checked. The water boards get to do those themselves. The most dangerous ones are already changed. Not many of them still need to be changed.

What is special about the Kandertal when it comes to flood risk management?

I do not think there are much differences with the other valleys.

Herr Fahrni told me that there are quite some cultural differences between the valleys. What difference do you think this makes?

The people are different in every valley. The challenges are the same however. We have to see how we manage to do the same with different people. Maybe it takes a little more time or effort, but the challenge is similar.

Are there aspects of the FRGA that are exemplary for other mountainous areas?

What I think is very good here is the gewässerrichtplan. It it important to have an overview. The municipalities now know what is expected of them and of the other municipalities and that gives them certainty. I think that would be a good thing for other areas as well.

Are there special challenges for this area?
The most urgent challenge is simply to fix the deficits that we have found. Urgent is difficult to say, but we have to do it now. Kandergrund, Frutigen and Reichenbach have some deficits that need to be fixed as soon as possible.
How do the evacuation plans function in the area?
You have probably already heard this in other interviews, but we are only sidewise involved in that. The municipalities need to make the emergency plans. The municipalities can base these on the Gefahrenkarten. The fire department then has to make sure the emergency plans are functional. That all works well in the canton Bern.
Herr Hitz told me that the consequences of climate change are clearly visible in the Lütschine area. Are the effects also visible in the Kandertal?
We have certain measurements of the last decades that can give multiple interpretations. It is difficult to say. We can see that since 1987 more big flood events have taken place in the area.
How does the cooperation within the OIK function?
The exchange of ideas and information is here, within the parameters of the time. We can do that weekly. We meet weekly. The information exchange is important and I think that is done properly. It can always improve, but it is good the way it is.

How is the cooperation with and among the municipalities?
I don`t think the exchange has become more intense since the gewässerrichtplan. I think the gewässerrichtplan is a very strong basis however. The exchange was already very strong in my opinion. The exchange also happens when a small event happens. We also have the planning and projects that make people talk together. We talk with the water boards and the municipalities. We look at the problems together.
Can you tell me something about the revitalisation projects above Reichenbach?
There are different projects. Since 2006 we have planned some of these projects. Some are still in planning. These revitalisation projects are just as important as the flood risk management measures themselves. We need to give the water some more space, so it can become more natural, ecologically better and also the soil can stabilise. On top of that the people can enjoy the nature again. That is also part of the water construction.
How are the local people made aware of the local risks?
The main reason people realise in what kind of area they live it through the events themselves. If a flood happens people will again realise that they are endangered and that they need to do something to stay safe. On top of that we have the Gefahrenkarten, which are public. Every municipality has one of these cards and people can see where their house is on these maps. That shows clearly what the local risks are.
To really be aware of the risks, a flood event would be necessary however?
No, that is not what I say. That is of course the moment when people really are aware of the problems. When a flood event has happened then the people all agree that something has to happen. I have read an article that says people forget an event like that in about seven years. When there is no event the awareness is lower, but people are still made aware through for example the gefahrenkarten etc.
On top of that the fire department trains on the emergencies, and when people see them evacuate, they will realise they live in a zone that can potentially be endangered.
Are there any experimental projects in the area?
Yes. We always do the variant studies. Sometimes an experimental plan seems the best plan. For example in Kandersteg there is a very strict corner where the water has to take a bend. The new project was to put rocks in that bend. That is a very unconventional idea, but it turns out to work exactly how we want it to.
To what extent do you think the area is prepared for future challenges?

Above average good. We have had to go through a lot of big events in the last years. We learn from every one of these events. This new knowledge is already implemented in the new gewässerrichtplan. All in all this makes us well prepared for the future.
I have one thing to add. With every project we do not only focus on the attainment of a HQ100 protection level. We also look at what happens when more water comes. Where does the water go, what can we do to get it back in the riverbed etc. These measures can be mobile or of a different kind. These measures can make sure the water does not go through villages.
Can you give an example of this?
For example in Kandersteg we have something like this. Near the station, we have mobile dam that can go up in case of emergency. The water then follows the street instead of going through the village. In 2011 this plan was tested and it worked very well. Some weaknesses were still there, but they are improved now.
Kandersteg sounds very exemplary in this talk.
Yes, the pressure was high there, because of all the problems they have had in the past.
We live in a risk culture. We cannot prevent every danger entirely. We simply do not have the financial means to do so. So, we look very closely at what the biggest potential damage is, and then we focus on those and live with the rest of the danger.
Merci Viumau!

Schwellenkorporation Kandersteg: Urs Weibel

01-05-2018 in Thun
Interviewer: Steven Daniëls
Language: Hochdeutsch

Short introduction: My name is Steven Daniëls, I am a student in local environmental change and sustainable cities. I am currently doing my Master's thesis research into Swiss flood risk management, specifically on Resilience in mountainous flood risk management policy. The information given in this interview will be solely used for scientific purposes. If you are okay with it I will record it, so the interview can be transcribed. As I am originally Dutch, the final version of this interview will have to be in English, but we can do this conversation in German, and I will translate it later if that suits you better.

Herr Weiler: "I will do it in Hochdeutsch, to make it easier for you; English can be a bit difficult. It would be difficult for me to talk about all the terms."

Thank you very much, is it okay if I record it?

Herr Weiler: "of course"

Can you introduce yourself shortly, to specify your relation to flood risk management?

Herr Weiler: "My name is Urs Weiler, I am leader of the flood risk committee of Kandersteg (Präsident von der Schwellenkommission Kandersteg).

What is a Schwellenkorporation?
The flood risk committee Kandersteg is an independent organisation that was given the task of making sure Kandersteg does not get flooded. The municipality hired us to do that. That is different in different municipalities, some have a special institution like Kandersteg, in some municipalities, the municipalities do it themselves. We manage all the flood measures, inspect them, think about new options and work together with the canton and the unteringenieurkreis. The measures are built for a longer period of time, so the main occupation is to manage and repair the measures.

How do you get funded?
We get funded from the private properties that are located in the municipality. Every household and private institution has to pay a certain percentage of the worth of the protected property to us. For example, a household in a flood prone area is worth 200.000 Swiss Francs and has to pay 0.006 per cent to us. Then we get 120 CHF to use for protecting the municipality. We do repair measures, build new measures and ? We have just finished two big projects and have recently a new one. For the big projects we get a higher percentage from the canton than for the smaller repair measures.

How do you work together with the Canton?
The OIK tells us how high the flood risk measures must be. For example for some areas they want high water of once in a hundred years to be the norm, for another area they want HQ 300, depending on the possible damage. They will never pay for a very high safety standard, because it first needs to all be of a proper level. We have to then find out how to achieve that, which option is the cheapest and where the weaknesses are. Then we work together with the

Schwellenmeister from the unteringenieurskreis to talk about our plans. Finally we ask the OIK to help us fund the necessary measures and then we ask a construction company to start the work.

Has Kandersteg recently encountered floods?
Yes, in 2005, really big. In 2011, a little smaller.

Do these events mean you get more money for protection?
Not really. If there is a new flood event, that means we did not do our homework well enough. Either the guidelines by the canton were too low, or our constructions failed.

So there should not be any floods anymore?
There can still be floods of course. The water comes from the mountains and has to go somewhere, so some floods will always occur. The key is to make sure this water does as little damage as possible. We need to make sure that the water stays in the riverbeds and if it does not, that we lead it to a place where least damage can occur. In 2005 our measures were not good enough yet. In 2011 we just prevented a major catastrophe and now we should be safe with most floods. The problem is that I have seen in the years I have worked here the HQ300 already. This should mean that we would be in rest now, but that is of course not the case. It can even be higher next time.

Are there any measures taken by the local people to prevent high damages?
Yes! We tell the property owners where and when they are in danger. When they live near the Kander, they will be told by the Canton to do certain measures. They have to for example close of all windows on the lower grounds to prevent water coming into the cellars. Almost all people listen to this, because otherwise the insurance does not help them. In 2005 this did not function very well yet, but in 2011 this has proven to work very well. Only a few cellars still flooded in 2011.

In short we have to make sure firstly that the Kander does not go out of the riverbed. Secondly that if it does, we have to make sure it does not come in the valuable areas and thirdly that the damage if it does is as low as possible.

Do you have anything to do with the Kander 2050 project?
We are actually quite close to function well enough to accomplish all the requirements of that project. We get water from two big valleys. The Gasterntal and the Uschinental. There the water comes from and we know that the material that comes from those water would be devastating for our village. Luckily, the way the valleys are structured, the most of the rock stays in these valleys, which means we are safe for now. If these valleys are really full, we have a problem, as the valleys cannot be reached with big enough machines. The valleys are not very populated however, so as long as certain borders are not reached, we can let nature do what it does in those valleys. The local farmers do not like this, but the Canton simply says that it is not economically viable to do something about it and we as a municipality hide behind the canton in this regard.

In the valley of Kandersteg itself we do everything to keep the damage as low as possible and we do not let nature have its way, but in the Gasterntal, we simply cannot do this.

Do you think the Kandersteg area is exemplary for other areas?
That is a bit exaggerated. I think we have been lucky here. We have invested a lot. But we were lucky to have started a project that we could change to prevent a catastrophe in 2011. When we

look at these project we have done all we could. My predecessors have done what they could and we benefit from that now. Now we have to go on with that and we do that. Look at for example the Oeschibach, where we are building a new measures. We are also lucky to have only one big river in our village. We defend ourselves for these problems, and then we let the water go down. The villages below us must solve their own problems.

What is the biggest challenge for you here in Kandersteg?
We still have two rivers that have not been protected well enough yet. The Oeschibach and the Wätterbach still have to be changed, to make sure that even climate change cannot cause problems to our village.

What effect do you think Climate Change has for Kandersteg?
Currently a research project into permafrost has been started on the Doldenhorn near Kandersteg. That study will show to what extent extra material (rocks etc.) will come down with the water. This material can fill the riverbeds and cause floods. We need to decide whether we want to take out all this rock or let it go with the river and let lower villages deal with it. That is a thin line as we need to make sure the river does not become filled with rock, but we also need to keep some rock to make sure the measures stay in place and do not erode. Also to transport the rock is extremely expensive for us and we cannot do that.

Are there naturalisation projects in Kandersteg?
No, there is simply no space. We need the little bit of land we have for the farmers. We do still have some natural areas, such as in the gasterntal, but in the valley of Kandersteg we cannot do that. Reichenbach, lower, has an exemplary naturalisation project, we cannot do that.

Are there any experimental or innovative projects in the area to prepare for future challenges?
Experimentation on flood risk management measures is not a good idea as we simply do not have the means and it is not economically viable. Of course we do look at the different options we have, but we cannot experiment. We look at the costs and the effects of the different options and we look at the models. We also work together with companies that have a lot of experience, like from Interlaken and Spiez, and we look at the cheapest and best options there as well.

How do you think future challenges are taken into account?
Well the studies like the one on the Doldenhorn and also our project at the Oeschibach need to be examined. If it turns out that we can keep the rock where it is supposed to be, then I think the future does not hold too big challenges that we need to do something about. The first study (LLA study) has shown that the biggest challenge is avalanches form the side of Oeschinensee and we need to make sure that we can keep an eventual flood from there can be kept out of the campsite and also out of the main village. Therefore we need to make sure we can lead the river into the forest, and if we can manage that, the biggest risk will be over.

Do the Gefahrenkarten have any influence and effect on the safety of Kandersteg?
They are very good. The gefahrenkarten are brandnew (2016), so we have to see what they do in the future, but if anyone now wants to build in the red or blue zones then they have to ask special permission to the OIK, which they will not get easily. The cards are based on studies like the LLA study, which show where the main natural risks are and naturally people should not live in areas with highest risk, so the OIK keeps them out of these.

How does it work with eventual evacuations?

We have three levels of warning. If it is the first level than we send people to look at the weak spots. With a second level warning we start to tell people to prepare themselves for floods and we bring out machines to clear some places. At the third level everything is prepared for the catastrophe and even the army gets called in to help the local people. In 2017 we have had an almost flood, where everything was prepared, but we were very lucky and the water remained in the river bed. Five centimeters higher and we would have had damages. It was a good test run and everyone did what they had to do.

Do you have anything else to add, what I have not asked yet?
Kandersteg is a beautiful town, but we need to understand that it will always have to live with the dangers of its location. The bridges will always be dangerous objects and we must continue to make sure we keep our people safe and make compromises to build as safe as possible.

Tiefbauamt Gemeinde Frutigen: Simon Bircher

02-05-2018 in Frutigen
Interviewer: Steven Daniëls
Language: Hochdeutsch

Can you shortly explain what your role is in the flood risk management policy of the municipality of Frutigen?

My name is Simon Bircher, I am part of the Tiefbauamt Frutigen, for 2 and a half years now. I am responsible for constructions, traffic and waterworks, so everything that has to do with water or traffic falls under my jurisdiction, and besides that all constructions in our municipality. The bauverwaltung has 8 employees with a total of 6 fte.

When we look at flood risk management, we currently have two big projects going on in our municipality: the Engstlige and the Kander. They are both being planned right now. Next to those two main rivers we have numerous small side rivers. These are still natural, because the terrain is too steep to change the rivers.

So the Tiefbauamt takes the place of a Schwellenkorporation and is a part of the Gemeindeverwaltung?

Correct, we do not have a Schwellenkorporation anymore. We used to have three different ones, but in the 1980s they stopped, for a reason I do not know exactly and now the municipality has taken on their job. So now, the flood risk management has to be paid from the taxbudget, giving us limited possibilities. Sadly the bad weather does not ask for the budget.

I have read that the main flood events in the region were in 2005 and 2011. How did these floods affect the municipality of Frutigen?

Yes, in 2005 and 2011 the Kander flooded parts of the neighbourhood called Kanderbrück. These events were quite costly for this area. The Engstlige did not flood during these two flood events, but did come very close to flooding the village in july 2015. Then a peak rain event upstream in Adelboden caused a flash flood that rose almost to the bridges of the village. Luckily there was still about ten centimetres between the water and the bridges, otherwise the damage could have been a catastrophe. This shows that the Engstlige is also very dangerous. This event was a once in 30 years event and all waterworks should be able to cope with a once in a 100 years event. They do not now.

How do you work together with surrounding municipalities and the Canton?

All municipalities have to stick with the cantonal plans of the Kander 2050 project. That means that all villages must reach the HQ100 aim. How the municipalities reach this goal is their own business and we have to make our own plans to reach it. We do have one project together with Reichenbach i. K. but that project is mostly for them and only 100 metres falls is part of the gemeinde Frutigen, so we do not have too much interest in that project, that is mostly theirs. We do talk about that of course.

What do the two big projects you talked about mean?

The Kander project would mean a straightening of the river kander near kanderbrück, so the capacity of this part of the river increases. This project would also try to heighten the dikes around it and lower the riverbed, so floods can be prevented. This project would cost seven million.

The Engstlige project aims at a heightening of the river dams to safeguard the village from floods. Ideally, we would like to give the water more space, but the houses are built right next to the river so this is not possible. This project would cost 5 million.

Sadly, the local people voted not to grant us the money. They disliked the lengthiness of the planning process and the local people that live right next to the Kander did not want the river course to change, because that would mean they would no longer live next to the river. These people convinced the rest of the town to vote

against the plans and now we have to start all over again and the planning process will take even longer. The projects should start 2020, but that is not going to happen now. Frutigen has 6700 inhabitants and sometimes it looks as if we have 6700 waterengineers.

Does this mean that the local flood safety is lower than surrounding municipalities now?

Yes, it is certainly suboptimal now. The civilians that voted against were just really frustrated about the lengthiness of the project and now they still have nothing. We lacked the political will to change simply say this is what we need to do, so now just do it. With different changes in personel etc. this did not work. But historically we have very good protection. The current flood walls are very old, and are reason to call some of these measures historical monuments. We need to therefore also look at how to preserve some of that.

What are the main challenges here?

We have sole erosion and rocks and material. We need to make sure that not too much rocks lay in the river here in the village, because than the walls become too low. We also need to make sure however that the water cannot erode too much so we need to make sure that there is some material in the water, but not too much. We looked at different options, like a wood restrainer, but these take too much material out of the water. So for now we stick with the old mining ground above the village where the rock is taken out of the riverbed. On the short term the biggest challenge for us is to get the acceptance of the local people to start with the necessary projects. On a longer term we need to make sure we have everything at least as high as the HQ100 requires of us as with climate change I believe the amount of flood events will increase.

What does the municipality do to get the people involved in lowering the damage?

We have made all our paperwork public so the people could vote on the item and knew what to vote. Furthermore, we hoped that the voting itself would activate the people. Now we started a committee where people can join to look at the problems in our village and to solve them. I hope we get a lot of people involved in this manner. But we still need to make sure that we as a municipality reach the goals that the canton asks of us.

So the actual problem is that the municipality has two major dangerous rivers that are both very expensive?

Yes it is too expensive, but the problem is mainly the local inhabitants on the riverside of the Kander. Their problem is not the flood risk management but their private interests.

What else do you do to lower the potential damage of flood risks?

We have very elaborate evacuation plans from the fire department. Everyone, even the trains are involved in that evacuation plans. Furthermore the danger cards are very helpful. They make sure people do not build in the dangerous areas.

Are there any experimental/innovative projects going on in Frutigen?

Two experimental projects have been presented in the planning phase. A local inhabitant who has gained some insight from Finland presented one project. That project could not work in our fast flowing river. The other was with the wood retainer, but that took too much material out of the water.

All in all, do you think the area is ready for the future uncertainty and challenges?

I think it is very good, when we get to do the two major projects. Without these two projects we are not safe. Kandergründ for example gets wet feet with a flood event of HQ30. With a HQ100 the entire village of Frutigen could be in trouble. The damage potential is very high of course!

Merci viumau.

Lütschine Interview Transcripts

Content:

OIK I (Lütschine): Oliver Hitz

24-05-2018 in Thun
Interviewer: Steven Daniëls
Language: Hochdeutsch
Short introduction of the research

Could you please introduce yourself and your role in the flood risk management in the Bernese Oberland?

My name is Oliver Hitz, I am a water engineer at the OIK 1 (OIK). I am responsible mostly for the area around Interlaken and the Lütschinentäler until the Brienzersee. My goal is mostly to advise the local flood risk management practitioners on the flood risk management projects, mostly the Schwellenkorporationen (water boards). Some municipalities do not have a water board however, then I directly advise the municipality.

Are there such municipalities in the Lütschinentäler?

Not really. There are some in my area however, but they are next to the big lakes. Isseltwald and Niederried, but they are not near the Lütschine. They are next to the lake.

When and how did you start this job?

I am in the OIK for ten years now. I studied forestry and directly after my doctorate I started here as a water engineer. I have always been responsible for this same area around Interlaken.

Can you tell me something about the biggest floods that occurred in this area?

Well, you have heard about the 2005 floods of course. The exciting thing about the Lütschine is that the bigger events happened after 2000, whereas we have records that go back about a hundred years. The 2005 was obviously the biggest event, both in amount of water and in consequences.

I heard that in 2011 Lauterbrunnen suffered from a flood as well, is that correct?

Yes, that event focussed on the Weisse Lütschine. So that was mostly a problem for the Lauterbrunnen area. The consequences were rather small however.

Are the materials that come down from the mountains a major problem for the Lütschinen area?

Yes, in these alpine areas the amount of materials that can come down is unlimited. With big floods that means a lot of materials will come down as well. These materials form a large part of the problem for the local villages.

Is this problem mostly for the higher villages (in this case Lauterbrunnen and Grindelwald) that are closest to the glaciers or also for the lower ones?

Not necessarily. We have special circumstances in the entire area. That means there are many spots where the riverbed can rise, which can cause problems. It is however the case that the gradient is lowering when you reach the lower parts of the valley. Therefore the biggest problems might be in Lauterbrunnen and Grindelwald as that is closest to the source of the problem, but the problems are not necessarily restricted to these parts. For example, in Zweilütschinen both rivers join and that causes problems as well. That happened in 2005 and in 2011.

Is this problem tackled by material retaining areas?

In Grindelwald we have two glaciers which sometimes give problems. They are both retreating. This causes a lot of materials to break loose and come down. This has caused some problems. Grindelwald has tried to tackle this problem by specifying an area to keep this rock there. This area is levelled and there can be no buildings in this area. This is a very big example that we only have in Grindelwald. Every municipality has its own specific problems. In Lauterbrunnen we have similar retaining areas, but they are a lot smaller. The glaciers cause a lot less problems in that area.

What trend can be seen when we look at these materials?
The frozen areas are defrosting which causes more materials to come down. The smaller creeks do not follow this trend. They mostly react to a big rain event. These are a little more calculable. You can see where materials are loose and it is calculable how much will come down and how big a retainer should be in place to protect the infrastructure.
The local expert in the Bödeli (lower) area told me that the amount of materials that reaches that area is lowering. Can you explain that?
It is very difficult to trace that back to a cause. What we can see is that an event like the 2005 flood event has put a lot of materials in motion. As this event is becoming quite far in the past, the soil is stabilising. On top of that many municipalities empty the riverbeds to make sure the amount of water that can pass their village is big enough. This material cannot reach the Brienzersee either. These two things can explain the lower amount of materials in the lower parts. Bödeli süd has done the same by the way.
What is the biggest challenge for the future safety of the Lütschine area when it comes to flood risks?
There are two major challenges. Firstly there is the entire climate regime that changes. This can cause the permafrost to defrost, the rain that intensifies, the materials to come down etc.
The second major challenge is the retreating glaciers that can cause glacier lakes, create extra sources of materials and that no longer form a barrier for the water to flow down.
So, can the retaining areas form the solution to the main challenges?
Well, there are two sides to the challenge. The materials are one side of the problem and the enormous amounts of water that come down form the second. With new projects we try to look forward and anticipate enormous amounts of water. The projects do need a certain flexibility to be able to deal with an extreme amount of water. With the new projects we also look at these extreme options. That is something that will definitely help us in the future. The other thing is the political options. The global issues that I hope will be tackled, through political debate. There is of course nothing we can do about that here that will impact the global warming.
In the Kandertal and the Haslital there is a Gewässerrichtplan. Why is there no such thing for the Lütschinen area?
No, there is not. The new law that stems from 2014 is active. This law tells us that we need a regional plan. The catchment areas are the main focus in that new law. Before these laws the municipalities were responsible for all of the flood risk measures. The only exceptions were the big rivers and lakes. The new law states that the canton is responsible for the Aare and the major lakes. On top of that the bigger catchment areas must have a Gewässerrichtplan. There is a list of ten to fifteen rivers that need such a plan. The Lütschine is on that list, together with the Kander and the hasliaare. The other two areas have already started with this plan, whereas the Lütschine still has to start. The next years we will start with one as well.
Is there a reason these rivers are first?
Resources are the only cause. No, there are some more reasons. There is a prioritisation behind the list. We can`t make all the plans at the same time. This prioritisation is based on the problems at hand. The problems in the Haslital and the Kandertal were bigger than here apparently. The Kander even started with the plan before the revision of the law. Here in the Lütschinentäler are fewer municipalities that take part. On top of that we have good water boards that work together well. The cooperation was already existent. Therefore it did not have the same priority here.
In the Lütschinenarea there are only four water boards?
Five, Lauterbrunnen, Grindelwald, Bödeli Süd, Lütschental and Gündlischwand.
So, it works very well in this area because there are so few water boards.

It is hard for me to make a comparison with a different area as I am only responsible for this area. Here I think the communication goes well. The water boards take it seriously and have taken a lot of action since the floods of 2005.

Is the Bödeli Süd cooperation of multiple municipalities an example for you?

It has advantages and disadvantages. In the case of Bödeli Süd I think it is a very good thing. They are all connected to the Lütschine, even though they might not have the Lütschine flow over their area. This gives them a sense of togetherness and it gives them the means to counter the problems. There are municipalities that have a smaller interest in the cooperation, such as Saxeten, but they are able to manage it themselves. It is more of a partnership than a dependence on each other.

In Lütschental I heard that the projects that the canton wanted them to do are finished. Are they finished now?

Every water board is autonomous on its own area. They function to their own needs. We give them advice, but we do not force them to do something. There are some national criteria for a waterproject, that is how it is. As Lütschental is a very small municipality with few bigger areas of built ground. With a big flood the Lütschine will go out of the riverbed in Lütschental, but that is not too big a problem in that area as there are very few buildings. They are at the same level as many other villages however.

Are there big differences between the different municipalities in the Lütschinentäler?

The main difference is based on the damage potential. A bigger village that is close to the river needs better protection than a village that is a bit higher and a lot smaller. We are not allowed to invest more than the damage potential shows as potential costs. We economise the damages. This means that bigger villages such as Interlaken have a lot more robust systems than a small village. Lütschental is a bit of a special case. They were hit really hard by the 2005 floods. So they needed urgent help. This was too much for their financial means so they were subsidised heavily by the state and the canton. Normally Lütschental would not be able to spend this much on flood risk management, but now the problem was very urgent.

The Gefahrenkarten are made by the municipalities. Do you have any role in them?

The municipality is responsible for the safety of its inhabitants. There are more challenges when it comes to safety of which floods are only one part. We as experts help the municipalities to make and to check the gefahrenkarten. Based on these cards we then have a look at the possibilities to lower the risks and for that we then work together with the water boards.

In Lauterbrunnen for example we see a big part of red on the cards. That is a priority for you to lower this risk then?

When the damage potential in the area is high then it becomes a priority. When the damage potential is low, construction in that area is impossible for private individuals, but there is no direct problem. We have defence goals and if these are not met then we have defence deficits. Those are the main priorities. The human lives are the main factor involved in these defence goals. Our main priority is to save lives. Second goal is to prevent or lower damage to properties. When a red zone is in a village then it is a priority. When it is just a farming area then there is no big problem.

I remember in Lauterbrunnen there is a campsite in a red zone, how does that work?

Campsites are a very difficult theme. We have a lot of campsites in dangerous zones. The campsites are obviously very sensitive to floods. When the red zone is because of avalanches then there is no big problem because avalanches are a winter problem and in winter most campsites are closed. When it is a flood risk then it can be a serious problem. The focus is then on emergency plans and evacuation.

Do you have anything to do with the formation of these emergency plans?

The fire department in cooperation with the municipality makes these plans. I am only indirectly involved in this planning phase. The plans that are made by the municipalities are mostly meant for the fire department.

We are only a part to this in the formation phase. The ambt für bevölkerungsschutz, sport und Militär is the main cantonal organ that is responsible for this. We only show where the weak spots are. A local company that has a building in the dangerous area has a responsibility to have plans for evacuation, such as the owner of the campsite.
We are also responsible for the permissions to build in dangerous areas, so we can ask for better evacuation plans etc.

Are there big renaturalisation areas in the Lütschine area?

Not so many. Renaturalisation is a difficult theme. Most municipalities/water boards that are responsible for water management see their responsibility primarily as flood prevention. Water management should have two parts however, the prevention of floods and revitalisation. Mostly the second part only comes when there is a special opportunity for this. When people see that there is both a flood and ecological deficit, then one project can help both aspects. Pure revitalisation projects are very scarce. Most of them are in the smaller creeks and not in the main river. There is reason to want that in the main river as well, but the water boards do not feel for this very much.

Do you do anything to move this along?

We try. Even the Canton and the National government tries to do something. Renaturalisation projects are very well subsidised. In that way we try to move this along. In the water boards there is a meeting, where all the locals come together. They decide if something happens. When the people do not want it then it does not happen. We can make a plan without asking the local water boards. We never use this option however, definitely not for renaturalisation. When people are in serious danger we might do it, but that is it.

Does it happen that a plan comes from a water board but that the people do not vote for that option?

No, in my area I have not encountered this. Mostly when a project is initiated there is a serious reason to start that project and then the local people can understand this problem. It is of course important to show the people the information they need to understand a plan. Therefore this will not happen with most flood measures. I can imagine this would happen with revitalisation measures. I could imagine that the local people would say "no, this much money we will not spend on revitalisation." Especially when there are still defence deficits.

Below Lauterbrunnen there is a very expensive project that takes the fish into account. Is that vulnerable to the vote of the people?

That is a very exciting project yes. The measure is old and needs to be replaced. It is hard for the people to understand why we do not simply rebuild the old measure as that worked fine. The new law specifies certain ecological needs. The old measure does not meet these needs and therefore needs to be changed. That can be hard to explain to the locals however.

Are there any experimental measures in the area?

The project on the Bödeli is very special of course. We try to reach a very high defence potential. Even above HQ300 will be reached. The potential damage is very high in this area, so we have to do something. On top of that we have done some studies into the changing circumstances in the Lütschine. Floods seem to become more frequent and more heavy especially in this area. The system is changing and where it is heading we do not know. Therefore we decided to reach for very ambitious goals to ensure the safety of a large part of the Bödeli. That means the defence goals are very high in the area.

The Lütschine is an exception in that regard?

Yes, we have already had this plan for a very long time and we have realised that it is rather easily attainable, so we decided to simply do it. We realise now that it is not as easy as we thought but every project is different so we go on to realise the safety of our civilians. Normally our goal is HQ100, but in special cases when we

have to safe lives we can strive for higher goals. That would also depend on the costs and the benefits of a certain project. All in all it is quite exceptional in Switzerland to strive for such high goals however.
Another reason why we are a special case is that the measurements of the last hundred years show a very clear trend that floods occur more often and more heavily in the Lütschinental. This is more clear in our valley than in others. The cause for that is hard to say.

How often do you talk together with the other experts of the OIK?

Not too often. We have a leader, Damian Stoffel, with whom we have regular contact. The exchange of information through him goes very well. When we need some information I mostly ask him. On top of that we have three or four big engineering companies that know a lot about the problems and that work in the different valleys. They also help to exchange the information between the valleys.
Some of these companies also come from other parts of the country, which helps to exchange information nationwide. We also have a day to exchange knowledge with the different OIKs of different cantons. All in all we have quite a lot of contacts like this.

Are there any specific problems that only happen in the Berner Oberland?

Not really. The last years we have seen a lot of places where the ice is retreating, but this is a problem that is nationwide or even worldwide. Therefore, we can talk about that with other parts of the country. Every project is a bit different though. Many aspects cause this difference, political circumstances as well as geographical ones and cultural ones. I think the personal differences between water boards and other organisations are also very important. One leader has a lot more to say than another. These individuals can make a lot of difference.

Is the Lütschine area in your opinion exemplary for other mountainous areas to follow?

It is a very interesting and exciting area. It has a lot of interesting challenges. There are many exciting problems that need to be solved and sometimes have been solved. Some aspects of that could be interesting for other areas as well.

Are there any urgent problems today that need to be addressed?

All of the water boards, except at the moment maybe Lütschental and Gündlischwand have projects going on that need to be finished.
I brought some pieces that might help you to understand our case even better. *shows maps*. Most of it you have already asked very specifically. Here are the measures that can be taken by the canton, and a paper with the emergency plans of the area. We have had all this. Here you also see a map of the 2005 flood event and the precipitation.
Merci Viumau!

Schwellenkorporation Lütschental: Hansueli Teuscher

16-05-2018 in Lütschental
Interviewer: Steven Daniëls
Language: Hochdeutsch
Short introduction of the research project. Is it okay if I record this conversation? Yes. We can hold this conversation in English or in Hochdeutsch, what do you prefer? Hochdeutsch bitte.

Could you please tell me what you do in the SchwellenKorporation Lütschental?

I am the president of the SK Lütschental. I am in the SK for ten years now. We are responsible for the watercourses in the valley in our municipality. We have the Schwarze Lütschine and circa 20 side creeks coming down from the mountains, ending in the Schwarzer Lütschine. Most of the side creeks have been changed, to stop the bedload (geschiebe) from reaching the main river. All of these projects have been finished in 2013.

The main goal of our organisation is therefore right now to check the rivers, if the detainers are not full. To check after a storm if everything is still in order. Since 2005 we changed everything.

So 2005 is the big flood event here in the valley. Can you tell me some more about that?

In 2005 we had the last big flood event. We did not have any casualties, but we did have a lot of damage in our municipality.

What has changed since 2005?

Since 2005 the Lütschine has been given more space. A retaining area was built above the village, to stop the bedload from reaching lower villages like Wilderswil. I will show it to you on the map. One minute. *shows the changed areas on the map*. So this is the area where the land has been lowered and where the river was given more space. That is the only prevention measure that has been taken. In the rest of the watercourse, we cannot build any prevention measure. The water is so quick here. If bad weather causes a flood in Grindelwald it will be here in half an hour and we have to be prepared, there is nothing then that we can do.

Where were the main damages in 2005?

Here just above the Bahnhof everything was flooded and big parts of the road were gone. It was really bad at the time. On top of that all of the small creeks were very high and flooded the area as well. It truly was a catastrophe. All we could do was help the people to reach a safe place.

Wow, okay. Do you think enough has been done to prevent such a catastrophe here in the near future?

We made all changes to all the small river creeks. Mostly for the material that could come down. That is as much as we can do to prevent it.

Is the village currently safe from an HQ100 event, or is HQ30 enough here?

I think most of the village is safe from an HQ100 event now. There are quite a few families living here and therefore there is quite some effort put into this area to safeguard it from future events.

How does it work here with the Gefahrenkarten here?

I have nothing to do with those, I think that is the municipality in combination with the canton that show how endangered an area is. These cards are very helpful to show where the dangers are and where the people can build.

How do you work together with other municipalities? For example, you just said that the detaining area is also functional for Wilderswil. Did you talk about it with them before building it?

No, no, we did not talk about that. The canton just told us that we needed to build that and then we built it. We had to do that. And we had to pay for it as well, although we did get a lot of money for it from the canton.

Are there any special characteristics that are special for this area?
The main difference with other areas is that it is so steep. When something happens above us then it will be here really quick. We therefore can hardly protect a house or something with sandbags because you cant fix that in such a timespan.
So the only thing you can do is to have good evacuation plans in such instances?
Yes, since 2005 we have made evacuation plans in cooperation with the fire department. We have not been able to try these yet, as we have luckily not been endangered since then, but I think they work well.
And the local people know what to do in such an instance?
Yes, the fire department would coordinate that and bring the people to safety.
Are there any parts of the local FRM that are very good and should be applied in other areas as well?
I don`t think we did so much different than other municipalities. In other areas like ours they also have the retainers, which is a good thing. More we cannot do actually. That is the best we can do.
Are there any things that need to be changed before a new flood event?
Right now we think (and the canton thinks) that we have done what we have to do. Everything that needed to be changed since 2005 is changed and the whole project was finished in 2013.
Do you think an event like 2005 could happen again?
This question you cannot answer with yes or no. Then all of the wood and material that came down locked the bridges and caused the biggest problem. For example the main bridge in the village was blocked and than caused the main problem. The bridge is changed now, so more water can flow through and I think if we can do this to all bridges, if all bridges are safe, than we will not have the problems that we had in 2005.
Is there any renaturalisation going on in the area?
Apart from the retaining zone we did not have any of that no. In Grindelwald they have a similar retaining zone and we have good contact with them. We had good contact whilst building that at least. Now, as we have no ongoing projects, we do not need to speak with other municipalities.
How does it work with the insurances in this area?
In 2005 the National and cantonal government took 99 per cent of the damage, so we could survive, to clean up. Right now when a retainer fills up it costs us a lot of money. We are a small municipality so we do not have much financial means, so than we ask the canton for help.
How do you get funded?
We get around 50.000 per year from the local property owners to keep them safe.
And how does it work with the private insurances?
Everyone can insure themselves, and we also have the buildings insurance, so people are very well insured in the area.
Do the local people still make sure they do not have any damage in case of emergency?
It is difficult to make sure you don't have damage. When for example the water here from above comes down then we have water on three sides and there is not much we can do.
Do the buildings get any preparation for emergencies, like extra stability etc.?
No.
How do the local people know when a flood event takes place?
The fire department is responsible for that. We have a big siren in the village that people will hear when the water comes. When the sirens go now than the fire department knows exactly what to do.
And the local people, do they know as well?
They will check their own houses and maybe help the neighbours, and then leave to the safe place.
What are the biggest future challenges here in Lütschental, for example Climate change, permafrost?

Uhm, here on the one side we have the Männlichen so no permafrost, and the other side is also okay. I don`t think that is a problem. Only maybe something comes from Wilderswil but there is nothing we can do in that case. We cannot build walls of three meters higher to protect everything. In that regard our village might be a bit difficult for your research. So all we have is the retaining area.
In Wilderswil there was a spontaneous Glacier lake that grew all of a sudden and then emptied again really quickly, for such instances we now have the retaining area. Furthermore I don`t think there will be very big challenges.

So the retaining area was built in 2007, was that experimental back then?

It was just what the canton told us to do so we did it. We do not know how to change an entire river ourselves so we rely on the people that do know about that.

How does it work now? There are no new projects. How do you work together with the canton now?

The canton does not come to us when they don`t have new projects and we don`t go to them unless we need them. Therefore, it's quiet now. When we need help it will be given to us, but for now, it is okay.

In conclusion, would you say that the area is well-prepared for future challenges?

I would say so yes. Extreme events can always happen of course, but we have done what we had to do. Nature cannot be predicted however.

Do you have anything to add?

You see the difficulty of our village that we have a special situation with the steep rock faces. That makes the problem fast. In 2005 for example we did what we could do but the village was still very much damaged.
Merci viumau!

Schwellenkorporation Lauterbrunnen: Ralf Schai

17-05-2018 in Lauterbrunnen
Interviewer: Steven Daniëls
Language: Hochdeutsch
short introduction of my research
Is it okay with you if this conversation is recorded?
Yes
Either we can have this conversation in Hochdeutsch or in English; sadly my Bärndütsch is not good enough yet. Which would you prefer?
Hochdeutsch please.
Could you please introduce yourself for the record?
My name is Ralf Schai and I am working for the wood service of the municipality of Lauterbrunnen. On top of that I am president of the Schwellenkorporation Lauterbrunnen, which is why you came to me for this interview. The SK Lauterbrunnen is responsible for all rivers in the municipality of Lauterbrunnen, circa 80 creeks. That is in the entire valley. So we are not part of the municipality, but the municipality has given us the responsibility for the safety of the water when it comes to flood risks. We get money from the municipality and from the private money that flows to us via property taxes. So we are not connected to it, but a loose organisation with its own board and everything. We do that as a `hobby` next to our normal jobs and everyone has its own part in it. For example the man you just met outside is responsible when it comes to checking the rivers for rocks and other materials and he then comes to me to tell me something has to happen. Every region has a different person doing that, so in Wengen I have someone responsible for that and in Mürren and in Stechelberg.
How long have you been a part of the SK Lauterbrunnen?
I am now president for 2 years and a year before that. I really like it, but it also costs a lot of time. It is very interesting, but timewise very challenging. When we have different meetings I have to be in all and we have a lot of different projects going on right now.
Can you tell me something about these projects?
For example we have been busy with the Mattenbach behind Stechelberg. There we had to do something to make the flood risk smaller. Next to that we have a lot of small projects such as the Lauibach outside of the building here. I have to go to look at that with an engineer to see what is possible there. He will propose plans for it than. Many of those projects are going on these days.
Can you tell me something about the last big flood event in the region here?
The 2005 flood was the biggest flood event in the region. That was very damaging, but we also had the 2011 floods that was probably when we look at the amount of water even bigger here. I think maybe the 2011 floods were a bit more local than the 2005 floods, but here we also had some big damages in 2011.
Has anything changed since these big events?
Along the Lütschine we have made some changes to the valley. We built some dams along the river and lowered some of the terrain so the damages are lower when a new event comes. Now the houses and the infrastructure should be protected better.
Has anything been done to the smaller creeks as well?
Yes, we have one retainer above in one of the smaller creeks. Furthermore we are planning one of the smaller creeks to have one as well. The Mattenbach has a retainer as well, but we have so many of those little creeks that we can`t change them all. We also changed a bridge so that everything can flow through. All in all we have so many projects.

Maybe Avalanches form a big risk here as well? How do you deal with that?
Yes, but avalanches are more dangerous but also more calculable. The Swiss people have learned to calculate exactly where comes the avalanche and what can it harm there. So to me that is a more calculable risk than the flood risk. In the avalanche winter of 1999, we had the last two casualties with avalanches and since then I think we handle that very well. With a flood we cannot predict it so easily and now the climate change will have an effect on that as well. Therefore, we do not know exactly what to expect. I think it is safe to say that we can see a development where more floods happen and also bigger floods happen so that frightens me more.
What is exactly the problem with the climate change to your knowledge?
Both the amount of water will rise because we will see more heavy rainfall, but also the melting of the permafrost causes more material to come down. Both problems can be problematic for our village as we are very high up in the mountains. The glaciers will let some more rocks go as they melt and there might be glacierlakes that fill and then empty really quickly again which could cause a flood as well. Thunderstorm tend to have more energy in them and that can cause problems. Last year we saw a big thunderstorm that remained on the Schwarzmönch for a long time and that caused a lot of water and materials to come towards Stechelberg. These are scenarios that we have to deal with.
So floods might become more frequent in the near future?
Yes, I think that is a very real risk. I think we can be certain of that. Up on the Rottalglacier we have already had incidents as well. That was not even big rainfall, it was just extreme melting that caused a lot of rocks and water to come down. That blocked a bridge and then caused a little flood as well.
Is there anything you can do against such events?
There is not much we can do. That is very difficult. We have once thought about making a very big retaining area above the village. We have the room for that, but we decided not to do it. We cannot do these really big things. Maybe if a few more catastrophes hit us, we might do such big things but for now, we do not really see the necessity to start such really big and costly operations. Now that is just to expensive and we don`t even know if it would really help.
Why would it not help?
In Grindelwald they have a similar project which has been functional for some time. So much material comes down from the glaciers there that they have to take out the bedload very often. They don`t know where to go with all of this material and this problem will continue forever. This is not a sustainable solution, and furthermore it is very expensive to take all of the material out every time. They do not know where to put the material now.
We have not started to do something about this problem, because it is not a simple problem and so far the Lütschine takes all of the material down and we do not have to do anything about that. Therefore, we would like to keep it as good as it is now, without taking all of the problems as our responsibility as they did in Grindelwald.
Are there any other innovative or experimental projects going on here in Lauterbrunnen?
Hmm, what is innovative, and what not. Sandweidli, which you passed with the train, there we have a waterfall that cannot be crossed by the fish. There we are currently building fish steps so the fish can reach our village again. *shows pictures*. We made some plans with the Uni Rapperswil. This is the model which shows how it will look. We want to make a fish steps there. The old waterfall there shows damages and we are not allowed to build waterfalls anymore, as they are not ecologically defendable. We have to take ecology into account and therefore we will build this below our village. The entire thing will cost six million Swiss Francs. The Canton, the SBB (railways) and the nation will pay for a large part of the project however. The railway is right next to it, and as it also protects their interest they will pay their part as well.

Do you know about the HQ risk assessment?
Yes.
How high are you trying to make the HQ in Lauterbrunnen?
We try with most of our projects to reach HQ300, so we can be safe for most flood events. Not everywhere, this is attainable however. Further back in the Mattenbach we can only reach HQ100 for example, but we try mostly to reach HQ300. That is the goal, but it can also be very costly.
Do you think there is any extra interest in Lauterbrunnen because of the high tourism?
Bottomline that does not make much difference. It is mostly about securing the houses and the inhabitants. The only thing that might change is the infrastructure. Because of all the tourists the infrastructure is used more and is therefore maybe more valuable, but bottom line is that there is not much more money available for our village than for other villages. The main difference is that some municipalities are a bit smaller, which causes them to have a lower budget, but I don`t think tourism is a very important factor there.
How do you work together with the OIK, with Oliver Hitz in this case?
Oliver is a very important adviser for me personally as he is the expert I look to when I have to decide on water related questions. When I go to look at a new project he looks with me and tells me what the advantages of certain options are. Furthermore he is very helpful when it comes to contacts with higher levels of bureaucracy.
Do you also talk about flood risk projects with other municipalities in the area?
Sometimes, not too often. We are a very separated and isolated area, that does not have to do with other municipalities. Mürren, Stechelberg, Wengen and Lauterbrunnen are all part of our municipality and SK, so we don`t need other municipalities here. We talk sometimes with Gündlischwand which is a lower municipality, but not too often. The LLE (document on causes of the floods in 2011) we made together, that happened together with the OIK as well. Next to that we don`t speak with each other too often.
How does the Gefahrenkarten work in your opinion, I have seen there is still quite some red in this village?
Yes, there are so many dangers here. We have avalanches, mud streams, rock falling, floods etc. We assessed all of the dangers and made a list of them, which is the most urgent etc. We gave this to an engineering bureau and they assessed what is really the most dangerous and what should be done first and now we are just starting at the top of this list and work our way down. Only with creeks we already have 80 or 90 creeks that are potentially dangerous. We can`t fix these all at once, so we start with the most dangerous and go on. Reaching number 90 might not happen in the next hundred years. These risks are assessed using the risk of casualties and the risk of potential damage.
Which aspects of the local FRM strategy should be implemented in other mountainous regions as well?
Uhm, we have a relatively good financial situation, so that is a good example for other areas. We also try to be offensive when it comes to measures. If something is necessary, we do it quickly. We have seen that when we do something, we immediately see the results, maybe houses that are no longer in the red zone etc. So we are very decisive in that sense.
What are the main challenges now?
First, we need to fix the waterfall, which is the first thing that has to happen now. After that, we must change somethings in Mürren, we need to build a retainer in Mürren. However, these are smaller projects. In Wengen etc.
The main challenge is actually that we need to make our village more safe, whilst changing as little as possible to the Lütschine. If we change to much there, the material might not flow down to the Brienzersee anymore and then we could be in serious trouble as that would be both dangerous and very costly.

Are there evacuation plans in place in the municipality?
Yes, we have evacuation plans. The fire department has to make those and they are also responsible for the execution of these plans. We have the Notfallplannung. We were one of the first to participate in this. That should work. Furthermore we looked at some glaciers, if they are not too unstable, and made evacuation plans for that etc. We looked at how much time we have etc. So normally we have the notfallplanung and per extension some special cases.
Do the local people also know what to do in case of emergency?
Yes, most of them know. The fire department is very well equipped and they are trained for those cases. Even the campsite has evacuation plans, so everyone knows who is responsible for which part of the evacuation.
Renaturalisation, do you also have that?
Yes, down here in the village there is a part which we are restructuring. The river will get a little more space, but not too much as that might stop the transport of the materials. That project will be finished in three years. We have already done some renaturalisation in many smaller creeks, Schützenbach, Rotenbach, etc. which are already changed to give them more space. My predecessor always said: These projects get almost complete funding from the canton, so do those to give something back to nature. So you do something against floods at one time and the next time you give something back to nature. We have done that quite a few times.
Are any changes made to buildings to make them more resilient to floods?
No, nothing comes to mind. With avalanches we do have that, but not for floods that I know. When someone lives in the red zone, he simply cannot build. I don`t know if he would be allowed to change his building to make it more stable. The boss of the campsite build some flood prevention measures himself. We would like to do something there, but then a part of his campsite would have to be closed down, as it is very close to the river and he does not want it closed down. At the moment, we will not force him to yet.
How are the local people made aware of the flood risk?
In the case of emergency the fire department will do that. We used to have sirens to alarm people, but those are only allowed in the case of a real catastrophe. When a dam breaks or so, than the sirens would be on, but otherwise it doesn`t happen.
The local people know about the dangers of living in this area. With all the dangers we have, they learn soon enough.
Tourists cannot know all of this though?
Yes, exactly, they don`t know a lot about this. We have to take some extra measures because of this. When part of the glacier came down we closed all near hiking paths to ensure the tourists would not go there to see the event. We have to be extra careful because of them.
In conclusion, do you think the area is prepared for future challenges?
Hmm, that I cannot say. We have done what we can do, with what we know now. Nature can do what it wants however. The Lütschine and all of the small rivers cannot do anything out of the ordinary for a hundred years, or they can all flood at once tomorrow. Nature is incalculable in that regard. An event like that in 2005 and 2011 can happen again. I would like to see how our measures would function in such an event, but we are never completely safe in this area. We can do, and we have done whatever we could do, but I always think that tomorrow something bad can happen and that we should be prepared for that. Especially climate change will bring new challenges and that is something to keep in mind. The Glaciers are far away, but the materials come closer and closer to us.
Are there any studies conducted on these developments?
There has been a study to show where possible glacier lakes could be, but the exact impact to us is still unclear for most floods. It is too expensive for us to do such research.

Merci viumau!

Schwellenkorporation Bödeli Süd: Ritschard Matthias

21-05-2018 in Matten bei Interlaken
Interviewer: Steven Daniëls
Language: Hochdeutsch
Short explanation of my occupation and research

Can you start with a short explanation of your role with the Waterboard (Schwellenkorporation Bödeli süd)?

I am the president of the waterboard Bödeli Süd. The waterboard exists since 1994. Before that it was called "Korporation der vereinigte Lütschinen" (Cooperation of the united Lütschinen). That existed for 120 years. In total we exist over 140 years therefore. Our predecessors have determined that it is bad when every municipality has to deal with the flood risk for themselves and they have therefore united in the cooperation. That was originally with Zweilütschinen, Wilderswil, Matten and Bönigen. Since 1994 we have a new name, because a few other municipalities joined the cooperation, Saxeten and Gsteigwiler. Now it is Bödeli süd.

How does this cooperation function?

Every municipality has two people in the board, one for the (ground)property representation and one for the municipality itself. That are in total 12 board members. There is one more in the board, that is the "Vertreter der Werke" (Representative of the public works). He is responsible for the electricity cables, tv cables, railways, sewage canals etc. All of the things that we have to take into account that are under the ground but that play an important role. So in total we have 13 board members.

How did this organisation form in the cantonal law?

The state of Switzerland has given the responsibility for flood risk management to the cantons. The canton of Bern gave it in turn to the municipality. Every municipality is therefore responsible for its own water management. The municipality then gave this task to the schwellenkorporation and as I just told you, they decided to work together as it is a common problem. Mostly because there were so many different little rivers.

How do you get financed?

We are financed through the Schwellentellen. Those are part of the taxes. The local people pay a certain percentage of their property value to be protected from the water. On top of that we get a lot of subvention from the canton, depending on the magnitude of a project.

Why are these municipalities together in the waterboard and not for example Lütschental or Lauterbrunnen?

That is difficult to answer. It has been this way for 140 years. It works, so we keep it this way. We work together to fix our problems. For example with the Glacierlake above Grindelwald, something had to be done. So we, as we had the biggest risk, the most people live in our territory, we had to pay some 80 %. That is just how it works. Even though the problem was not on our territory.

Did any floods occur in the last decades?

Yes, in 2005 there was a really big flood event. That was the last really big one. The Lütschine went over the dams in Wilderswil and caused a lot of problems. The Standbach, the Saxetbach and many other rivers did similar things and that all caused much damage. *shows pictures*.

Did any other events occur?

In 2009 we had a small event, but the damage was low, then. It just took us some hours of work and we had to rent some machines, but that was all. A few more times we had some highwater, but effectively there was no damage, because we restructured the area since 2005. Since 2005 we started the Hochwasserschutzplan Bödeli. We are still busy with the last parts of this project, but this I think has lowered the risk immensely.

Can you tell me something about these projects?
We have different projects. The biggest river is the Lütschine. Then we have many different ones. The biggest problem is therefore the Lütschine and the Standbach, because that area is really densely populated. And then we have 72 other rivers.
The biggest project we have is the Hochwasserschutzplan Bödeli. That is mainly about the Lütschine. We cannot change the course of the river because of all the buildings and cables in the ground etc. Giving the river more space is therefore no option below Wilderswil. We therefore built some dams, for example in Bönigen. On top of that we are going to make two different exits for the water. The water will be flowing over the former airport to the Brienzersee. So we have certain bridges that cannot handle extreme water amounts, so before those bridges we have made options to let the water flow over the land. The one in Gsteig will flow through the soon-to build- tunnel towards the Briezersee. The other one will flow over the former airport and the highway. That is quite special, to be allowed to flood a highway, but there is no other option. That way we should have a lot less damage from floods. These emergency channels will only be used in the case of a HQ 300 event. The chance that something likes this is needed is very low therefore. We are lucky to be able to build to an HQ300 standard, in other areas they cannot do that. We will reach this with all the projects that are currently finished and still being incorporated. Above Wilderswil we have given the water some more space. That is difficult, because the farmers do not want to leave the land, but we have bought some land. People know we need the land, so when people have some land to spare, we buy it. That is also on our website.
So now everything is now HQ300?
When we have finished all of our projects then the Lütschine will be HQ300. Right now we are still in the middle of these projects, so we do not reach HQ300 yet. In Wilderswil is for example nothing changed yet. We have started to look at this area, and started planning, but the first change is yet to be made. Most of these projects will start somewhere this year or next years. In Bönigen, we have almost finished. There we built new dams.
Do the materials that come from higher grounds form a problem for this area?
Depends on who you ask. The monks that changed the course of the Lütschine towards the Brienzersee have in my eyes done a very good job. They really looked at the river well and they have managed to get the materials with the river into the Brienzersee.
There are also people, mostly older people, that do not agree. These old people believe that an old man near Wilderswil went to the river with a chain and walked over the banks of material when a certain moon shone. A few days later these banks would be gone. Those are mystical traditional stories in which I do not really believe. Since I joined the Waterboard, we have taken materials out of the river maybe three times. Most of the times the river does this all by itself however. The problem is mainly that the fish die when we do this. In the delta of the Brienzersee, the materials are taken out anyways. They can take out 45.000 m3 per year of materials. They don`t reach this in the last years however. The amount of materials is lower. Nature gives us less materials here the last couple of years.
Maybe that has something to do with all the retaining areas higher in the mountains?
No, it is nature that gives us less materials. The last couple of years we have seen less materials in almost all sidecreeks in the area. Everyone you talk to says so.
We must realise here that we must not only focus on the Lütschine but also on the smaller creeks. These also have some retainers. Mostly to ensure the safety of the infrastructure.
How do the Gefahrenkarten function in the area here?
With the Gefahrenkarten we have nothing to do. That is the responsibility of the municipality and the kanton. We do look at it of course. It is useful to look at in the planning and of course we try to make red zones into

blue ones etc. But we do not make them ourselves. I did hear that Gsteigwiler will soon change their gefahrenkarten. That is interesting for us, as we can see what changes our projects have made.
We sometimes attend the meetings about the gefahrenkarten as we know most about the weaknesses in flood risk management and we can help the municipalities with these things.

Are there any aspects of the FRGA that are exemplary for other municipalities?

We work together very well with different communities, that is pretty good. Some others have similar cooperation. The cooperation with different municipalities, also with municipalities that are not in our cooperation works outstanding. Especially when waters flow over the borders of municipalities, I think cooperation is a must. The cooperation must not be too big too handle however. That is the balance we must try to maintain. So why do we not add Lauterbrunnen, or Grindelwald? That is why. It would become unattainable to work together with so many municipalities.

Is this organisation not too big too handle either then?

Well, we all work voluntarily. I am currently occupied for about 20 % with the presidency and it must not become too much more. When you also add Grindelwald it would become too big for voluntary work. In our organisation where we are responsible for so many different creeks, we have to work together and it makes absolute sense.

How do you work together with the Canton and the OIK?

We work very well together. I can always call with Ricarda or Oliver if I need them. They are always there for me when I need a real expert on the job. I am very grateful for their presence. I am very happy.
The Ambtschwellenmeister and strasseninspektor is Ricarda Bender she is my first go to. I am often in contact with them. We are the locals they are the professionals.

Do you also talk with the other municipalities upstream, like Grindelwald and Lauterbrunnen?

We talk together, but not often. We know who we are, but we do not look for contact. We do not need them. As long as everything goes well, there is no need for us to talk to them.

The evacuationplans are part of the fire departments responsibilities; do you have anything to do with that?

When a flood event happens? We are only responsible for flood risk management. During an event we are not needed. We have no say in what happens then. We do have a Schwellenmeister and she is there. On top of that we are almost always at the spot. We do not have to, but we know what is happening and we want to know how it works. When a real event happens the first call goes to the fire department and if it is too big for them to the RFO (Regional ..?). They know we are there however and we have some knowledge. We tell them what the problems are as well. It is almost family.

You said something about renaturalisation already, can you tell me some more about that?

Well, of course we give the river some more space above Wilderswil. The former airport is also a very big part that will be used for renaturalisation. On all other parts we simply have no room to give to the river. We do put rocks and trees in the water for the fish to have some slower water for the fish.

Are the local people made aware of the local risks they take by living near the river?

I will say it straight. No. Is there a risk, mwah. The people that live here for a long time know that it is a possibility, but when someone just starts to live here than they do not know about the risks. They only know when something happens, when it is probably too late.

What is a future challenge for this area?

Awareness creation of the local people. All in all people forget about really quickly. After 2005, people were aware for maybe two years that similar things could happen again. If you ask them now, they will tell you no such thing can happen in the area. If you then show them pictures of 2005 they respond "that is not here is

it?" They have simply forgotten. When they have forgotten about this possibility, they do not agree with what we want to build.
Politically, we have a good situation. We have enough money. We receive enough help from the canton and everyone. So that is all very good.

Does climate change have any effect on this area?

I am not a geologist, not an engineer, but I say yes. I think future storms will bring more water to our area. In shorter time, more water will come down. But I cannot prove that. In our area we also have some permafrost. But that is all the way behind Lauterbrunnen and Grindelwald, so those rocks will not reach our area.

Are there any innovative projects in the area here?

The future tunnel that can be used as an emergency channel is quite innovative. We can work together with the highway organisation and that is quite a challenging idea. Both the emergency exits are quite innovative to us anyways as you need to make sure that it does not become the main river. Not too much water can go through those. When do you open them? Do you let them open naturally etc.
Other innovative projects we have are the Druckenbrucke, a bridge that pushes the water down. We also have an old bridge that can be heightened to ensure its safety. These two are quite innovative as well.

In conclusion, to what extent do you think the Bödeli süd area is prepared for the future?

People do not have to worry. We have built for an HQ300. So that is very high. We do still have to deal with the uncertainty of nature. I cannot say that we will not have any future problems. Next week, so much water can come down that we do not know how to deal with it. When the project is finished, we have done what we can do, but still things can happen.
Merci Viumau!

Hasli-Aare Interview Transcripts
Content:

1) **OIK I & II: Damian Stoffel & Adrian Fahrni**
2) **Schwellenkorporation Innertkirchen: Andreas Banholzer**

OIK I & II, (Hasli-Aare): Damian Stoffel & Adrian Fahrni

22-05-2018 in Bern
Interviewer: Steven Daniëls
Language: Hochdeutsch
F= Adrian Fahrni (OIK II)
S= Damian Stoffel (OIK I)
Short explanation of my research
Could you please introduce yourselves and your functions in the OIK Bern?
F: My name is Adrian Fahrni, I am a water engineer in the OIK II of the canton of Bern. The canton has been split into four different OIK groups. OIK II is responsible mainly for the Mittelland and thereby for the Aare from the Aare Gorge all the way to the lakes in the west. The canton is split up into the four sections to make sure we can really understand our area and to make sure that we can go to our working area as often as necessary.
I am responsible for the big parts of the Aare. My personal responsibility to look into the Aare Gorge to Brienzersee section is the reason I thought it would be useful to contribute to this interview. I am educated to be a water engineer and I have been in the OIK for twenty years now.
Thank you very much. What is your task mister Stoffel?
S: My name is Damian Stoffel, I am in the OIK I in Thun. I am also a water engineer. I am at the OIK for 12 years now. First, I was responsible for the Diemtigtal area, but since christmas I am responsible for the Oberhaslital. So after a personnel change I became responsible for the oberhaslital area. That means I am responsible for Innertkirchen and everything above it (Gadmen, Gutannen etc). On top of that I am responsible for the municipalities beneath the Aare Gorge. Mister Fahrni is solely responsible for the Aare in this area, whereas I am responsible for everything else. So I also advice the Waterboards in the lower municipalities such as Meiringen. The municipalities are responsible for all flowing water except the Aare. They give this responsibility often to the Waterboards. We check them if they do well and mostly we advise them from an expert point of view. They also have to ask us for permission if they want to build somewhere in a blue area (moderately dangerous area). On top of that we help the waterboards to finance the projects they need to protect their village from floods.
How does your cooperation differ between the different waterboards?
S: Firstly I must add that not every municipality has a waterboard. They get to decide this for themselves. If a municipality has only one small river than the work can often be done by the municipality itself, but if there are a lot of small rivers than most municipalities have their own waterboard, which in my eyes is a very good thing. Many of these waterboards stem from a long tradition, in which a village had to deal with a severe danger of flooding. They then formed a waterboard so the people could work together to counter the local problems. Some of the municipalities also have a municipality cooperation among a couple of municipalities, where different municipalities together form one water board.
F: I think the water boards also stem from the old laws from before 1989. In those laws the local property owners had to do their own part in the flood risk management. If you lived next to the river, you had to make sure that your land was safe. This meant you had to do some handwork as well as pay some fees. Because the local property owners could not do this all by themselves they formed water boards to cooperate on this. Differences I do also notice in a positive sense. In a Water board the same people are responsible for a longer time span. A person generally joins the water board when he is around 30 and then stays until he is well in his 70`s. That means this person has a lot of knowledge about what has happened in the past, what is dangerous, what can we do about it etc. This experience is a very good thing also as a help to us. When there is no water

board the personnel might change every four years and they have to start over every four years as well. I therefore favour the water boards very much. That is the biggest difference. Water boards are more professional, dot! No doubt about that.
S: They are of course specialised in the flood risk management task. If a municipality wants to do such a thing, they have to do it in the public works department. This often means they have to let the people decide whether they want the money to go to building a new school or a flood measure. This discussion does not occur when a water board gets money through taxes and this money is simply dedicated to flood protection. We can see more differences between the municipalities. It depends on the municipality whether they have five projects going on or whether they start in five years with a new planning. That has to do with the leadership in the water board or municipality but also on the dangers and circumstances in the municipality. Some regions simply have a lot less dangers. When you have twenty different dangerous rivers than you have to stay on it, whether if you have only one you can have a break of a couple of years.
F: I also have the feeling that it has to do with the flood events. I could never act, it was always a matter of reaction. I am here for twenty years now and it has always been reaction to flood events. I could never plan ahead. The only time we act is when something has actually happened. That is the case in 95% of the cases. We are still in reaction now to the 2005 floods now. That is now 13 years ago.
Is that the last flood event in the area?
F: Yes, the last big ones. Since then we had some smaller one.
S: Yes, 2011 for example was more local. Especially in the Kandertal and the Lütschinental this was also quite a big event, but on the Aare it had less impact. It was a lot shorter, but bigger amounts water.
F: Yes, we have had many different smaller events, but the big one was 2005. That was devastating for the entire canton of Bern.
S: I think on the local level we can actually act. When a municipality sees a lot of red on its Gefahrenkarte, than it has to act to be able to grow as a municipality. They will therefore have to act, not just as a reaction to the flood event but also as a means to be able to grow as a community. They will try to do things to make a red zone blue or even yellow. As you know a red zone means you cannot build, a blue zone means you need to take precautionary measures and you need to ask us for permission. So people want to change their village into less red. Especially the municipalities with a lot of red zones will therefore take a lot of action to make this areas blue.
What is your part in these gefahrenkarten?
F: The municipalities have to make these cards, we fund them for 90%. The municipality has to do it, even though they don`t always want to.
Are there big differences between the upper part of the Hasli-tal and the lower part?
S: Yes, above we have the Spreitgraben. That is a little valley under the village of Gutannen. In the 1970s they built an avalanche gallery there. In 2008/9 a lot of rock came down the mountain again and that has caused a lot of material to come down the Aare to Innertkirchen as well. The road is endangered there. The Aare has come up a lot. There is also a very small village there of which we were not certain if it could stay where it is. Now it is a little more quiet there again, but it can happen again tomorrow. It is also a very steep area. A lot of avalanches cause quite some problems there. You have probably seen the retaining area in Innertkirchen, that was mainly built for this problem. Because of all the material the HQ in Innertkirchen to lower to maybe HQ10 whereas it should be HQ100. That was a very urgent situation.
F: Exactly and after Innertkirchen is the Aare Gorge and below that we have a flat valley which can flood. The materials will not reach this part of the area. That`s why I always say: up until Innertkirchen you are in serious danger, below Innertkirchen you can be flooded, but you can also swim, so there is no life-threatening danger.

When it comes to the bedload, the Aare functions very well by the way. The river is the most wide near the Aare Gorge and as it flattens it also becomes less wide, so all the materials are taken to the lake. In the Brienzersee, the material is taken out.
We do have some very old dams in the part near Meiringen which is dangerous. These also broke in the 2005 flood event, but these will soon be renewed and then most of the problems will be gone.
Is the Spreitlaui problem caused by permafrost melting?
S: Uhm, the area is very steep, so in the last area large parts of the rock simply came down. The material is very heavy and takes all the mud and everything down. This can be caused by permafrost melting.
F: I think it is one of the causes but it is probably the biggest cause. We see this a lot more and we will have to deal with similar problems more often in the future. In this area around 2500-3000 this will simply happen more often.
S: We have also seen this with the Rotlaui. In 2005 the Rotlaui gave a lot of material. This caused the Aare to change course, making it go through the village of Gutannen. That could happen in different areas.
Is that then caused by climate change?
F: That could very well be.
S: It could be that the melting of the permafrost causes such events to happen yes.
Is the melting of the glaciers a cause of extra caution in this area as well?
S: Not really. Under the glaciers this area has a lot of lakes (stauseen) which are able to absorb the materials as they are very big. In the future, the energy companies might have some problems with this, but the villages are safe on that regard.
On the triftglacier they have done some studies because they want to build a reservoir below it. These studies have also shown that there is no really big danger to be taken into account, when it comes to permafrost melting.
So the biggest challenges from climate change have been taken into account?
F: So far as we can see them now, yes, but we work with nature, so we can never be sure. But there have been different studies to show the biggest problems. The biggest problems are far in nature, so they do not form too big problems for society.
What is the standard for flood risks in the area?
F: We get the goals from the canton, so that certain areas that could have a more devastating consequence get better protection. The nuclear reaction here near Bern for example has a very very high standard. In the hasli tal we only have some villages, so most of the area is standardised with a goal of HQ100. More houses together means mostly HQ100. When smaller farmergroups are together then it goes down to HQ50 etc. We differentiate to fit the risks. The railways and the highway also have some extra protection.
In the Haslital we have a Gewässerrichtplan. This plan has a very elaborate structure and shows where which goals have to be set. This also shows where the water will go when a flood occurs. One rule counts in all those plans. The protection will never become worse than it is today. So everyone wins, but some win a lot more than others. ON top of that the plan shows ecology, material transportation etc.
Does the Gewässerrichtplan show the plans or the current situation?
F: It shows the current situation and the plans to improve on the current situation. It was agreed upon in 2014 and now we start the real planning. It might still take until 2025. When everything goes well, the planning phase takes about two years.
S: Two years is very optimistic. It can take five, sometimes even ten years, to only plan a project. Everyone gets a say in the process. The local property owners, forest, municipality etc. etc. To talk to all these people takes a lot of time and they all can disagree with the plans.
So for now, HQ30 in villages is still possible?

F: Yes, for example in Meiringen it is still HQ30. You can see that on the gefahrenkarten. This means the village has a lot of blue and red zones, causing the villagers to push for better flood measures.

In the end the highest HQ will be HQ100 in the area?

F: Well, some areas can simply not be flood geographically. If a village is high above the water, it will not be flooded with whatsoever flood. In the villages next to the water we aim for HQ100 however. There can be some HQ300 depending on the potential damage however.

S: Sometimes we can heighten one side of the riverbank so the river will in case of a flood event go out of its course on the one side, making the other side practically safe for a very big flood. In that sense you can make sure the bigger damage on one side can be prevented. We have that in our area as well.

F: We have to always taken into account how the water will flow if a very big flood comes. In this area we have shown that the biggest risk is on the left side of the river. That is where the water will go out, that is where the water will come. On the left side we have to therefore see how it reaches the Brienzersee on the left side then.

S: These are very nice examples. The state always shows the nicest examples of this. The problem is however that this is not always possible. Sometimes it is simply impossible to choose a side. How can you choose which city to flood. In the Wallis we saw that with Brig and Visp. Nobody wants to be on the worse side.

Are there any aspects of the FRGA in the Haslital that are exemplary for other mountainous areas?

F: This is a very difficult question. In the Haslital we have a very structured system because of the reservoirs. Under normal circumstances these reservoirs keep everything safe. With a flood event these reservoirs also help, but they do not do enough to keep you 100% safe. The main question here is how do we manage the bedload. The retaining area in Innertkirchen is a good example of this. We can take the material out there, we can put material in the river there to prevent erosion etc. Both a lack of materials and an overflow of materials are a realistic option and are potentially dangerous. How we handle this is very important in the future. Millions of cubic meters can come down the river. How we deal with this is a very special case here and people will look to us when it comes to questions about how to deal with this problem. When it comes to flood risk management itself there is not much specials going on here, but it is the way we deal with the materials that come down the mountain that is the main question. We are lucky that we have such good water boards because they also ask themselves how they can deal with this question in the future and that is important. What happens if Innertkirchen all of a sudden gets half a million cubic meters of rock, how can they deal with that, that is a question we have to ask ourselves and that is a question we do ask ourselves.

S: The way we deal with the differentiated risks on both sides of the rivers is also quite special, because of the length the river still has to go before the water can return in its normal course. If the water flows out in Meiringen we have to look all the way to the Brienzersee which objects the water will pass. That makes the project quite special as well. *shows it on the map*. These 15 kilometers will flood in case of a very high flood event. The entire right side is protected well, even though this side has a lot less valuable land. They are simply lucky that the railways are on a higher dam which protects the entire right side. If the railways was not here or was on the other side, the right side would be flooded.

Is there any object protection on the left side?

F: We are looking at that now, but it is difficult to protect all these farmhouses over 15 km. I can only protect those if the costs of building the protection is lower than the risk times the damage of the buildings I can protect with the measures. I think I will not be able to help them. I will have to show how this works though, because if you live here, you want to know why you don`t get any extra protection.

S: To get back to the question before; If you look higher up on the mountain you have the village of Gutannen. The road to this village is currently endangered from the avalanches and the other side of the valley is no possibility because it is even more dangerous. There we have an early warning system with sensors

in the mountain that show when something is moving and then turn the traffic lights to red so people are not endangered by possible avalanches. This is a very nice system we have.
F: When it comes to fishes we also have some exemplary aspects. We work in a fish habitat. The law tells us to keep that in mind. Therefore the ecological conditions cannot decline due to our work. We have to therefore take measures to help the fish to live in our waters. The habitat will be better most of the times than it was.
S: In the part near Innertkirchen we have a new project that tries to accommodate the fish in this restructured water. It is still hard, but we try.
Does that count as renaturalisation?
F: Renaturalisation is quite a proud word. Reichenbach, Husenbach, sytenwald those are our real renaturalisation projects in the area. These things for the fish are just necessary to keep the river life strong. Above Innertkirchen the river is still natural, so there we don`t need to change anything either. The only thing that happens there is the reservoirs.
Do you often speak together with the rest of the OIK about the other valleys in the OIK?
S: We do talk a lot with each other. When someone has a problem then they do ask around and asks for suggestion. It is going down a bit though. The water engineers in the OIK are more and more. Before when we were with only four or five it was very easy to talk to each other, but now we talk a little less. Especially the new employees know a little less people and that makes it maybe a bit harder.
F: I think it depends on the OIK. We have four different ones and every one has its own characteristics. For example the OIK I is from the Bernese Oberland. They know most about mountainous rivers. OIK II knows more about the lower lands. Within these groups we work together very well. Together with other OIK`s we might talk a bit less, but as long as we can do it within the OIK it is good, and for now it is good. Nationally we meet twice a year, which is not so much, but we don`t really need that. When I need something with a mountain river I know who to ask and that is important. Thanks to the national meetings we also know about the expertise of other cantons.
S: We also have a national coordinator that is involved in the biggest projects. So that goes for the 5 million + projects and we can ask the national coordinator. That coordinator can help us find the right person in other parts of the country as well.
Is there any difference between the different valleys in one OIK?
S: The municipalities are as you know mainly responsible so that is difficult to say. They do not have the expertise to make the plans themselves so they ask engineering companies to help them. They work in different places, making sure a certain knowledge spreads across the valleys. What we also see often, is that different plans are not possible and that in the end there is only one option. Then there are not many different options. That is less positive, because then the local people do not really have much of a say.
F: I think the differences between the different valleys are mostly non occurring when it comes to flood risk goals, or whatsoever. They come from the Canton, everyone has to do those. The differences between different municipalities is very big however. The circumstances in Brienz and Meiringen are so different that they are very hard to compare. The main differences that we do see stem from a cultural difference. You see that very well. The standards are the same, but the way to reach those standards is very different because of cultural differences. That is a little different if you compare Meiringen to Brienz and a lot different if you compare Meiringen to Frutigen. There you see big differences.
Who says which way is the best in which cultural area?
F: Well, that would be the water boards. They know the local circumstances the best and that is why they are there. They know the people, they know how to make things happen there. Our role is simply to help them to

do this well. As I am from Bern, I am not from the area. I am almost a foreigner to them, so I cannot convince all the people there, the people there have to convince each other.

Ahja, I have been to Frutigen, there the people decided they do not want to spend money on the waterprojects and then it simply does not happen?

F: When it comes to flood measures that can happen yes.

S: Frutigen is quite a special case. Frutigen does not have a water board and is from our point of view the municipality which needs a water board the most. Because there with the Engstligen and the Kander they have big problems. They have had a lot of problems with floods. Then the municipality says we need to do something and the people say, yes but not like this. Then decide to first renew the schoolhouse or whatever and then nothing happens. The opponents come to the municipalvotings and just vote against the proposal. Those are the costs of the Swiss democracy. Frutigen is very special in the fact that they have had so many wet feet, but still there is no action. Not even after 2005. In this valley people are also very conservative so they would rather keep things the way they did it fifty years ago. They do not want to start new projects.

Can you do anything to change that?

F: The canton could, if they wanted to, start the plannig without asking the municipality. Even if we do this however, the local people will always have a vote about what happens in their backyard and they can always stop it. In Lyss this happened and it worked out quite well. That was our coordinator who did that and I think it was a very wise decision, but it was also a political decision that can go wrong.

Such problems do not occur in the Hasli area?

F: I sure hope not. We are still in the planning phase so people still get to vote on some of the plans, so it can also be difficult here, but I hope not. 2005 is a little too far away. People are starting to forget how much impact that event had. Therefore, our plans will encounter quite some opposition, but I hope we will get it through nonetheless. The democracy also has big advantages. We get ideas from the local people that we would have never come up with, so that is very useful as well.

So in conclusion, can we say that the Hasli area is prepared for future challenges?

F: Yes. Firstly, the municipalities are really very good prepared for a possible event. The evacuation plans that the municipalities have are perfectly functional and the local people train on those as well. On top of that we have the gefahrenkarten. We know where the dangers are, we know what will happen and what we can do about it. That is organised very well too. So in the municipalities everything, also with the RFO works really well. I do not have the feeling that I will have to make an intervention of whatsoever kind.

S: That is perhaps the result of a trend that has been going on for the last twenty years. We have tried to work together with different organisations and when it comes to different natural hazards and that is working quite well. Everyone is working together, with the planners, the people at the brienzersee, that lower the waterlevel before a possible event etc. This cooperation is very important. Also when it comes to the local fire departments, they have the local knowledge, they get the gefahrenkarten and they find out what they can do. That is great.

When we look at the local people they also know how to live with the dangers. When a road has to be closed for three days there, they know what to do, they do not complain and just live in their village for a couple of days. When here in Bern, one street is closed for an hour, there is a lot more complaining going on. That is a very nice thing about the local people in the mountains.

Merci Viumau!

Schwellenkorporation Innertkirchen: Andreas Banholzer

03-05-2018 in Innertkirchen.
Interviewer: Steven Daniëls
Interview conducted in: Hochdeutsch
short introduction on my background and the research

Can you shortly introduce yourself and your position?

My name is Andreas Banholzer, I am president of the waterboard (SchwellenKorporation) Innertkirchen. I have been the president of the waterboard for the last 18 years. It remains interesting as we keep encountering new problems. The waterboard consists of five people from our village. We also get help from the finance advisor of the municipality of Gutannen, who advises us when it comes to financial questions.

How do you work together as a waterboard with the Gemeinde Innertkirchen?

We work together with the municipality of Gadmen. Together we have one waterboard. The people here in Innertkirchen pay more because they are exposed to a higher risk (2 promille). Above they pay 1.4 promille.

Did the major floods of 2005 and 2011 cause any damage in the region here?

Not too much. The 2005 floods were a big eye opener for the local people here and we used this flood event to really take action to safeguard our village from future floods, but the damage was low. We were lucky that the water didn't come over the dams. I have got some pictures. *shows pictures* Here you see the 2005 floods that led through the village of Gutannen. For us that meant that a lot of rock came to us through the Aare, but the dams did not break. We did have to take all the rock out of the water. When we had all the rock in the river we only had an HQ25, so we had to act. In 2008 we had another problem with the Spreitlaui. There came a lot of material to us again and we had to take it out again. The water itself is for us never the problem. When the situation is difficult the water can be kept back in the artificial lakes. The main problem for us is the water transports all the rock to our village and we need to get that out, otherwise our village is in danger. I have got a video of the main flood events. *shows video*. The video shows the project phases as well.

Can you explain the main flood measure projects in the area?

We have different projects. First we had the green phase, which started in 2010. This phase aimed to lower the really urgent risks. We heightened some of our dams and lowered the river to make the village safe. The second phase was the yellow phase. In this phase we created an area for the rock to slow down before the village. This area is realised and has proven to be very effective. The third phase, phase blue was actually the biggest part of the projects. In this phase we restructured the area to make the village safe (higher dams) but we also created space for the fish to breed and we rebuild the main bridges in the town. The last phase, phase red is still under construction, but this has less to do with flood risk management in our village. It focusses on the lower part of the Aare and aims to produce more energy from the river and gives the fish more space to breed in the lower part of the river. The lower part has never caused much flood problems. There are also not many buildings that can be damage. All in all is along our village the HQ now between HQ100 and HQ300, depending on the amount of material in the river.

So Innertkirchen is rather safe now from future flood events, does that mean you do not have other measures anymore (such as gefahrenkarten etc.)?

We used to have a lot of measures like that. For example there were lines hanging down from the bridge and if the yellow line was reached by the water than the fire department would have to come out. If the red line was reached than the people should be evacuated. These measures are still in place, as well as the gefahrenkarten, but they need to be revised as the urgency is much lower due to the measures. Our

waterboard cannot revise these measures however, as that is the responsibility of the municipality, the fire department and the canton.
The flood risk management in Innertkirchen is already very old. Already in 1893 the first projects started to canalise the Aare. That was some proper engineering as they had to build all the measures by hand. We still enjoy the benefits from this beautiful piece of engineering.

Do you have any renaturalisation projects?

Together with the entire Hasli-Aare area we work together to give the fish a natural place to breed. The seeforelle needs very special conditions. They come from the Brienzersee and need a place to breed. We have done a lot to make this happen, but the focus for this renaturalisation is mainly ecological. We are also prohibited to do construction in the water in the time that the fish come here.

Are there also insurance options here?

We have a cantonal insurance for the buildings. People need to do something about floods. Property owners get payed the first time they get damage, but not a second time and definitely not a third time, so when something happens you need to make sure it doesn't happen again. That also goes for normal floods (pluvial), not just for the Aare. For the land we have an insurance by the economic ministry but that works differently.

Do you closely work together with the OIK?

Yes, we had very close contacts. They were present at every meeting. Now there is a new leader and I haven`t met him yet.

How are these old measures challenged in the future?

Up in the mountains the permafrost is slowly melting. In the summer the heat breaks the rocks, in the winter this freezes again and in summer water comes in again. At some point the rock will just come down. This means that massive parts of rock are starting to come down to the river and we need to make sure that this does not block the river. Therefore the area in which we contain the rock now is very important in the future as I believe more and more rock will come down the Aare river. If we do not act on this, our village is in danger. But now that we have the retaining area, I believe we have countered this problem as much as we can. Of course nature remains uncertain, but we did what we could.

All in all would you say Innertkirchen is well prepared for eventual flood events?

At the moment I can sleep easily yes. Of course there will be new events. We have done all we could to prevent real catastrophes, but nature remains uncertain. The canton has done some research here because of the national road, and they found many spots that can cause dangerous situations, maybe these things happen next year, maybe they never happen. We cannot know.

Do you think Innertkirchen is an example for other mountainous areas to follow when it comes to flood risk management?

I think we have done all to mix the ecological needs with safety and I think we have done what we could to do this as well as possible. I think that is what is necessary to fit into the plans of the canton and to be prepared for the future. Some of the project were quite innovative and can be used by other communities, but flood risk management is different in every river.

Do you talk about flood risk management with neighbouring waterboards?

We never did that, but since the GEK (Gewässer Entwicklungs Konzept) we have had a few meetings together where we talked about this. We were able to exchange ideas, which is good. But there was also a lot of criticism.
Merci Viumau (Thank you very much!)

Appendix 4: List of Municipalities in the Case Study Region

List of Municipalities in the Case Study		
Municipality	**Population Size (JGK, 2018)**	**Water Boards**
Total case study Kander	**20.644**	**5**
Adelboden	3.370	Schwellenkorporation Adelboden
Aeschi	2.232	-
Frutigen	6.894	-
Kandergrund	798	Gesamtschwellenkorporation Kandergrund
Kandersteg	1.283	Schwellenkorporation Kandersteg
Reichenbach	3.604	Schwellenkorporation Reichenbach
Wimmis	2.463	Schwellenkorporation Wimmis
Total case study Lütschine	**21.966**	**5**
Bönigen	2.531	Schwellenkorporation Bödeli Süd
Grindelwald	3.818	Schwellenkorporation Grindelwald
Gsteigwiler	398	Schwellenkorporation Bödeli Süd
Gündlischwand	317	Schwellenkorporation Gündlischwand
Interlaken	5.673	Schwellenkorporation Bödeli Süd
Lauterbrunnen	2.406	Schwellenkorporation Lauterbrunnen
Lütschental	227	Schwellenkorporation Lütschental
Matten	4.040	Schwellenkorporation Bödeli Süd
Saxeten	98	Schwellenkorporation Bödeli Süd
Wilderswil	2.458	Schwellenkorporation Bödeli Süd
Total case study Hasli-Aare	**11.684**	**6**
Brienz	3.080	Schwellenkorporation Brienz
Brienzwiler	493	Schwellenkorporation Brienz

Guttannen	267	Schwellenkorporation Guttannen
Hasliberg	1.193	Schwellenkorporation Hasliberg
Hofstetten b. Brienz	287	Schwellenkorporation Brienz
Innertkirchen	1.087	Schwellenkorporation Innertkirchen
Meiringen	4.692	Schwellenkorporation Meiringen
Schattenhalb	585	Schwellenkorporation Schattenhalb

Table 1: Population of the municipalities in the case studies