*University of Bern - Institute of Political Science*

*Swiss Federal Institute for Forest, Snow and Landscape Research WSL*

# **Adaptation to climate change in practice**

# Overcoming the adaptation implementation gap in Switzerland

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## 1 Abstract

Climate change is one of the gravest problems society faces today and addressing it has proven to be challenging. After decades of national and international climate change mitigation policies that failed to produce consistently successful outcomes, climate change impacts now pose serious risks to human and environmental systems around the world. Although climate change mitigation efforts are ongoing, even the most optimistic scenarios project that climate change impacts and the risks associated with them will worsen in the decades to come. This situation is further aggravated by the delayed impact of successful climate change mitigation measures. More specifically, the impact of current mitigation efforts will not be realised for decades, so climate change developments over the next 20 to 30 years will primarily be determined by the lacklustre mitigation efforts of the recent past. Over the past 25 years, climate change adaptation has become an important secondary facet of climate policy for managing and minimising the damage caused by the now unavoidable impacts of climate change. Climate change adaptation efforts aim to reduce vulnerability to climate change impacts, manage the risks posed by climate change impacts and enable people to take advantage of opportunities provided by climate change. The importance of climate change adaptation is reflected in important international treaties on climate change, such as the Paris Agreement, which obligates signees to formulate and implement adaptation strategies. However, recent scientific assessments have identified a significant gap between the degree of adaptation needed to cope with current and projected climate change impacts and the adaptation measures that have been realised so far. While this gap between the degree of adaptation needed and the degree in place is most notable in developing countries, it persists even in some of the wealthiest countries of the world.

The adaptation gap in developed countries seems primarily rooted in a deficit in climate change adaptation policies and measures implemented. To fulfil the adaptation mandate accepted by signing the Paris Agreement, most Organisation for Economic Co-operation and Development (OECD) member states have formulated national adaptation strategies. These strategies commonly aim to reach adaptation goals by integrating them into various sectoral policies, assigning ownership of adaptation to the agencies responsible for the policy sectors that are most affected by climate change impacts. However, while adaptation goals have been integrated into various sectoral policies in this way, this integration has barely led to a correspondent shift in the working processes of the relevant sectoral agencies and not enough concrete adaptation measures have been realised.

This dissertation is intended to contribute to the search for solutions to this adaptation implementation gap. To that end, the dissertation presents an analysis of the current practice of climate change adaptation in Switzerland. The Alpine space is highly affected by climate change, with average temperature increases almost twice as high as they are globally and many aggravating natural

hazards as climate change impacts lead to more frequent and more intense extreme weather events and melt permafrost and glaciers. Switzerland as a very wealthy country with a long democratic tradition and ample access to well-educated professionals and innovative technology should be well-equipped to handle this challenge. Nevertheless, the signs pointing to an adaptation implementation gap in Switzerland are clear. No explicit legal mandate for climate change adaptation exists and the topic has barely entered local policy agendas, leaving adaptation measures rare and sporadic.

Based on an analytic framework that combines multi-level governance understanding of policy implementation with mainstreaming climate change adaptation, this dissertation investigates the processes by which climate change adaptation policies and measures are being implemented in Switzerland, identifying the actors that play key roles in these processes, the most important barriers and success factors relative to these processes and factors that may explain the participation of some scattered municipalities in adaptation measures. Based on these findings, I identified the most significant reasons for the Swiss adaptation implementation gap and provide recommendations on how to overcome or at least lessen that gap.

My findings show that, in the absence of the hard political power provided by clear legal mandates or responsibility for shared budgets, the coordinating environmental agencies at both the federal and cantonal level have relied on cooperative strategies to mainstream climate change adaptation into multiple sectors. This approach has enabled these agencies to implement win-win measures by piggybacking adaptation objectives onto ongoing processes with coherent goals and has also enabled them to garner funding for pilot projects that can serve as good practice examples going forward. However, due to a lack of sustained political commitment to promote and finance climate change adaptation, adaptation objectives are only integrated into institutionalised procedures where they align with existing sectoral goals. Conflicts of interest between existing sectoral goals and adaptation goals are either not addressed or are not resolved in favour of climate change adaptation. Additionally, the focus on promoting the horizontal mainstreaming of adaptation prevalent at the federal and cantonal level has resulted in a lack of top-down pressure to engage in adaptation, leaving local adaptation largely dependent upon local motivation and initiative and sporadic pilot projects. Indeed, my findings show that local climate change adaptation engagement primarily depends on perceived personal exposure. As such, I propose three primary approaches that can be employed concurrently to close the adaptation implementation gap in Switzerland: (1) formulate a clear regulatory mandate at the cantonal or federal level directing municipalities to take adaptation measures, (2) dedicate cantonal or federal level adaptation funding for interested municipalities and (3) conduct awareness raising measures on current climate change impacts and risks to increase perceived exposure among the Swiss populace.

## 2 Acknowledgements

When I was studying for my Master's degree I was working as a research assistant at the university and became friends with a few PHD students there. We would meet up for an after-work beer every other Thursday or so, they would tell me about how their dissertations were going, and I would think to myself "I am never going to do that, it sounds like the most stressful path I could possibly take". Almost seven years later, here I am finishing my dissertation. I'm not sure if it was the most stressful path I could have taken. Sometimes it certainly felt that way. The sheer scope and freedom of working on such a huge project can feel overwhelming at times. But working on this thesis has also granted me the opportunity to spend years researching a topic that is dear to my heart. To produce something meaningful. To choose my own research topics, questions, and methods and to invest in my personal education and development.

The chance to write my dissertation on an issue I am highly personally invested in was an important reason for me to reconsider my original stance on doing a PHD. However, what ultimately made up my mind was the easy camaraderie and friendship I had struck up with all my colleagues at the WSL. While writing my dissertation was in many ways a task I ultimately had to tackle on my own, it rarely felt that way. And so, I would like to take this opportunity to say thank you. To my supervisors Marco Pütz and Karin Ingold for all their support, expertise, patience, and time and for our pleasantly amicable and productive collaboration over these last four years. To all my former and current colleagues at the WSL for their friendship, their advice, and their willingness to entertain my penchant for unnecessarily passionate debates over anything and everything during our shared breaks. To the CCAMM program and my fellow participants in it for financing this journey and accompanying me on it. To my interview partners for taking the time to answer my questions carefully and competently.

And finally, I want to say thank you to my parents for encouraging my curiosity and my passion for reading and writing ever since I was a child. To my family, friends, and partners for all their love and support, for providing me inspiration and distraction when needed and for listening to my rants whenever the pressure got too much for me. I would never have found the strength and drive to finish this project without you.

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# 7 Introduction

Climate change is a global problem of arguably unprecedented proportions. Rising global temperatures pose exponentially increasing risks to both human and environmental systems (Intergovernmental Panel on Climate Change [IPCC], 2018). Climate change impacts are further exacerbated by potentially irreversible feedback processes that may cause global temperatures to continue rising even without any additional human influence (IPCC, 2018). In fact, one of the main goals of current international treaties for addressing anthropogenic climate change is to avoid triggering such irreversible feedback processes. Thus, the Paris Agreement, the most important such treaty at the time of this writing, aims to limit the increase in global average temperatures to less than 2°C compared to pre-industrial levels. However, recent studies have demonstrated that meeting the 2°C goal may not be enough to prevent further temperature increases due to the feedback processes (Steffen et al., 2018). Additionally, humanity currently seems unlikely to achieve the 2°C goal anyway (Raftery et al., 2017). Already, global average temperatures are about 1°C higher than they were 200 years ago, and climate change impacts are no longer just a looming future threat (IPCC, 2022). Climate change and the increased intensity and frequency of extreme weather events associated with it have had significant adverse effects on food production, water scarcity, health and well-being, as well as on settlements and infrastructures, throughout the world (IPCC, 2022). Climate change also has had severe adverse effects on ecosystems, causing huge shifts in species habitats and mass deaths. Already, the extinction of several species due to the impacts of climate change may be inevitable (IPCC, 2022).

The IPCC (2022) sums up the vast spectrum of potential adverse consequences of climate change for human and environmental systems as climate risks. Climate risks are the product of the interaction between climatic hazards and the vulnerability of the exposed systems. Vulnerability is defined by the IPCC as ‘the propensity or predisposition to be adversely affected’ (IPCC, 2022, p. 5). Vulnerability encompasses multiple concepts, such as sensitivity or susceptability to harm or the capacity (or lack thereof) to cope with harm and adapt.

In response to current and projected future impacts of anthropogenic climate change, the topic of adaptation to climate change has grown increasingly important in recent decades (Bauer et al., 2012; Lesnikowski et al., 2016). Adaptation aims to adjust systems in order to reduce climate risks and climate vulnerability and to take advantage of beneficial opportunities (IPCC, 2022). Arguably, human beings have been adapting to climate variability and changes in their environment for thousands of years. However, the impacts of anthropogenic climate change are unique in their scope, their intensity and, especially, in the speed at which they occur. Additionally, the global population growth within the last few centuries – combined with the concentration of population centres in areas exceptionally

exposed to climatic risks, such as coastal areas – further exacerbates the risks climate change poses to human systems. Thus, mitigating further climate change before its impacts become even more catastrophic, while simultaneously adapting to those climate change impacts that are already unavoidable, poses an unprecedented policy challenge of global proportions. Consequently, climate change adaptation has garnered increasing attention during recent decades in both policy practice and research (Adger et al., 2003, 2005, 2007; Albers et al., 2015; Bauer et al., 2012; Berrang-Ford et al., 2011; Biesbroek et al., 2010; Lesnikowski et al., 2016; Wamsler, 2014; Wamsler & Pauleit, 2016).

The Paris Agreement includes adaptation as an important secondary pillar of climate policies world-wide and obliges signees to formulate adaptation policies and measures. Most member states of the Organisation for Economic Cooperation and Development (OECD) have developed national adaptation strategies to fulfil this mandate (Swart et al., 2009). Many important adaptation measures have been implemented that have resulted in significant positive effects across all affected sectors and geographical regions over the last 25 years (IPCC, 2022). However, adaptation progress currently is unevenly distributed across countries, regions, cities and other settlements (IPCC, 2022). Indeed, national adaptation strategies are not comprehensively implemented into practice at sub-national levels, and local adaptation outputs remain scattered (Clar, 2019; Corfee-Morlot et al., 2011; Runhaar et al., 2018). This discrepancy between the status of adaptation implementation and the level of implementation required to reduce climate risks and vulnerability sufficiently to avoid severe damage to human and environmental systems is referred to as the adaptation gap. While this adaptation gap is disproportionately pronounced in developing countries and regions, it persists even in wealthy, developed nations (Berrang-Ford et al., 2011; Dupuis & Knoepfel, 2013; IPCC, 2022; Runhaar et al., 2018; Widmer, 2018). This leaves the question why even countries that have the means to adapt to the impacts of climate change fail to do so to a sufficient degree and what can be done about it.

## 8 Research question

To understand why national adaptation strategies struggle to produce the adaptation polices and outputs needed at different administrative levels to deal with expected climate change impacts, even in wealthy countries, this thesis presents an exploration of the current practice of climate change adaptation in Switzerland. The goal for this doctoral study was to understand how national level climate change adaptation policies and strategies are implemented into practice to produce policy outputs at multiple levels. What methods are employed to mainstream and implement adaptation goals? How and why are these approaches chosen? How successful are they? Finally, based on the answers to these questions, what conclusions can we draw regarding the reasons for the climate change adaptation implementation gap in Switzerland and potential avenues to overcome it? Thus, the overarching research question for this research was as follows:

*What are the main reasons for the climate change adaptation implementation gap in Switzerland, and how can it be overcome?*

To answer this question, I studied how Swiss climate change adaptation strategies and plans were being implemented into practice at the national, cantonal, and local level. I then identified the most important barriers to and opportunities for the design and implementation of climate change adaptation policies and measures in Switzerland, as well as the contexts and causal mechanisms underlying these influential factors. Furthermore, I researched which actors played key roles in Swiss climate change adaptation governance and why. Finally, I investigated which factors motivated actors to engage in climate change adaptation. Based on the findings, I then postulated the main reasons for the climate change adaptation gap in Switzerland and developed recommendations for ways to overcome this gap.

In the upcoming sections, I discuss the current literature on the climate change adaptation gap, including the most important related concepts, as well as the theoretical framework and research design for the study outlined in this dissertation. I then provide a brief overview of the three articles that represent the most important outputs of this research before presenting their results taken together and in the context of existing climate change adaptation literature. Next, I draw conclusions regarding the overarching research question of the thesis and explain how the thesis contributes to our knowledge of climate change adaptation governance. Finally, I present the three articles themselves.

# 9 State of the literature

The following chapter outlines the state of the scientific literature regarding the primary research object of this dissertation – the climate change adaptation gap and its persistence in both developing and developed nations and regions. The chapter goes on to discuss the state of the literature on two of the most influential concepts that have been employed to try and explain the climate change adaptation gap and to find ways to overcome it – adaptive capacity and barriers to adaptation – as well as their respective shortcomings and the research gap deriving therefrom.

## 9.1 The climate change adaptation gap

Despite significant efforts by the international community to foster and promote climate change adaptation, worldwide adaptation efforts currently fall short of the level required to prevent unacceptable damage to human and environmental systems (IPCC, 2022). The extent of this climate change adaptation gap varies across countries and geographical regions, and it is generally more pronounced in developing nations and regions (IPCC, 2022). Nevertheless, the adaptation gap is also prevalent among wealthy OECD member states (Berrang-Ford et al., 2011; Runhaar et al., 2018). Most OECD member states have formulated national adaptation strategies aiming to integrate adaptation goals into existing sectoral policies. However, this approach has so far failed to produce comprehensive adaptation outputs at sub-national levels (Corfee-Morlot et al., 2011; Dupuis & Knoepfel, 2013; Runhaar et al., 2018; Widmer, 2018). Additionally, current adaptation activities mostly aim to achieve incremental adjustments rather than transformational shifts and fall short of what is needed to deal with projected climate impacts, especially considering the recent, more pessimistic models for future CO2-equivalent emissions (IPCC, 2022).

This adaptation gap leaves human responses to climate change impacts largely reactive. Natural hazard management and our cultural approach to dealing with extreme events focus on repairing damages and restoring the previous conditions, a cultural norm that is reinforced by the systemic importance of insurance schemes and the political popularity of disaster aid measures that focus on helping victims by returning to the status quo as quickly as possible (Costi, 2020). Disaster relief efforts that produce immediate and highly visible results are more popular than adaptation efforts that reduce our vulnerability to impacts that may not actually take place for decades to come. However, while still vastly preferably to no adaptation at all, such short-term reactive approaches to climate change adaptation are expected to produce significantly greater financial costs and loss of life than proactive climate change adaptations (IPCC, 2022; Neumann et al., 2021)(IPCC, 2022; Neumann et al., 2021).

The adaptation gap is compounded by what Dupuis and Knoepfel called 'the implementation deficit of policies framed as climate change adaptation' (Dupuis & Knoepfel, 2013, p. 1), often simply referred to as the adaptation implementation gap: While adaptation policies have entered national and sub-national policy agendas worldwide, this has not resulted in the cross-sectoral prioritisation of adaptation goals (Berrang-Ford et al., 2011; Dupuis & Knoepfel, 2013; IPCC, 2022; Runhaar et al., 2018; Widmer, 2018). Higher administrative levels lack sufficient political commitment to sustain long-term priority shifts towards adaptation. Moreover, the implementation of adaptation policies is hindered by a lack of coordination, routines and practices promoting adaptation among important stakeholders (Runhaar et al., 2018). In addition, sectoral adaptation goals are only implemented into practice if they conform to established sectoral goals and priorities (Widmer, 2018), and adaptation goals and measures have yet to be sufficiently integrated into urban planning policies (Hurlimann et al., 2021).

In their meta-analysis of 140 case studies on adaptation mainstreaming, Runhaar et al. (2018) found that while adaptation mainstreaming produced policy outputs in almost every case, adaptation outcomes were only achieved in about 50% of cases. In other words, adaptation objectives were successfully mainstreamed into sectoral policies, plans and strategies, but often they did not reach concrete projects and activities, and thus, no tangible adaptation outcomes were achieved (Runhaar et al., 2018; Widmer, 2018). Similarly, Dupuis and Knoepfel (2013) compared adaptation progress in Switzerland and India and discovered that the national adaptation strategies in both countries primarily served as agenda-setting measures but had little direct impact on vulnerability to climate change. Adaptation policy researchers generally agree that coordination between sectors and administrative levels is the key to exploiting synergies and avoiding maladaptation, making it one of the most important success factors for adaptation (Keskitalo, 2010). However, in his case study of 14 adaptation strategy processes at multiple administrative levels, Clar (2019) showed that these processes rarely achieved the necessary levels of coordination and, as a result, often failed to meet their goals. While the involved actors all emphasised the importance of coordination during the planning phase, when referring to the implementation process, they generally focused on other aspects.

### 9.2 Adaptive Capacity

The climate change adaptation gap has inspired a host of research that has attempted to explain the gap and to find ways to close it. Early adaptation studies commonly investigated ways to measure and increase adaptive capacity. Similar to closely related concepts, such as resilience, adaptability, robustness or flexibility, adaptive capacity seeks to determine the ability of a system to adapt to

external shocks (Mortreux & Barnett, 2017; Smit & Wandel, 2006; Vallury et al., 2022). While exact definitions and operationalisations of these concepts vary, most studies agree that adaptive capacity varies but is interconnected across scales (Adger et al., 2004; Pahl-Wostl, 2009; Smit & Wandel, 2006). How well a municipality can adapt to the impacts of climate change depends, in part, on the adaptive capacity of the larger region or country that municipality belongs to and on the support these superordinate administrative levels can provide. Hence, adaptive capacity can be described as a function of many factors that may vary in importance from case to case and are usually themselves interconnected. For example, financial resources are an important determinant of adaptive capacity. At the same time, those resources are closely linked to other factors, such as the availability of qualified personnel and training opportunities or access to new technologies – factors that are themselves also important determinants of adaptive capacity. As the relative importance of the various determinants of adaptive capacity vary based on context, how exactly adaptive capacity can be operationalised has been the subject of many discussions (Smit & Wandel, 2006; Vallury et al., 2022).

Increasing adaptive capacity and reducing vulnerability to the impacts of climate change are two especially urgent goals for most developing countries (Turner, 2009). These countries and their citizens are generally less able to cope with the impacts of climate change because they lack the financial resources to do so. This issue is aggravated by the fact that the national economies of developing countries tend to rely more heavily on the primary economic sector, which is more vulnerable to climate change impacts (Turner, 2009). Therefore, article 4.4 of the United Nations Framework Convention on Climate Change (UNFCCC) obligates the developed party countries to financially assist adaptation efforts in those developing party countries that are particularly vulnerable to the adverse effects of climate change. This mandate increased the interest in studies that aimed to determine the relative climate change vulnerability and adaptive capacity of different countries and regions. Most of these adaptive capacity rankings operationalised adaptive capacity based on a number of quantitative indicators aggregated at the national level that were closely related to economic development (Dupuis & Knoepfel, 2013; Wolf, 2011). This conceptualisation of adaptive capacity seems plausible; moreover, it is relatively easy to measure and is very useful for determining where aid efforts should be focused. However, it largely fails to explain why adaptation implementation gaps persist even in wealthy industrialised countries (Dupuis & Knoepfel, 2013). More recent studies, therefore, have commonly focused on evaluating adaptive capacity at the individual and household levels and aggregating individual or household level data to assess adaptive capacity at the societal level (Vallury et al., 2022). Nevertheless, this approach, too, has been criticised for neglecting to consider the significance of interactions within and across scales (Elrick-Barr et al., 2022; Vallury et al., 2022). Additionally,

Mortreux et al. (2020) reported that high adaptive capacity as measured at the household level does not necessarily lead to adaptation.

The focus on reducing vulnerability to climate change and increasing adaptive capacity is also implicitly based on the assumption that adaptation will occur automatically in response to environmental changes when adaptive capacity is sufficiently high (Smit & Wandel, 2006; Turner, 2009). However, more recent studies describe this explanation of the policy implementation process as a bit too simplified. While adaptation deficits are generally more severe in less wealthy countries and regions, they are also present in developed countries and affluent regions (Berrang-Ford et al., 2011; Dupuis & Knoepfel, 2013; IPCC, 2022; Runhaar et al., 2018; Widmer, 2018). Dupuis and Knoepfel (2013) in particular, showed that policies and measures explicitly framed as targeting adaptation are more difficult to implement than policies that pursue similar goals but are not framed in that way. This clearly demonstrates that the reasons behind the adaptation implementation gap must be more complex than lack of funds alone.

### 9.3 Barriers to adaptation

Another strand of the literature on climate change adaptation policy and the adaptation gap focuses on what are identified as barriers to adaptation (Biesbroek et al., 2011, 2013; Eisenack et al., 2014; Moser & Ekstrom, 2010), which are factors that impede or prevent the design and implementation of adaptation policies and measures. Many climate change adaptation studies point to barriers to adaptation as the major culprits of adaptation gaps (Simoes et al., 2017; Valente & Veloso-Gomes, 2020). As such factors can take many forms, climate change adaptation research has identified a myriad of adaptation barriers. While useful for improving our understanding of the reasons adaptation is not progressing quickly enough to cope with all expected impacts of climate change, the compilation of barriers to adaptation suffers from its own issues. Studies have focused on different levels, sectors or geographical areas, have worked with differing theoretical frameworks and have employed different research methods (Biesbroek et al., 2011). This complicates the process of comparing the relative importance of multiple barriers to adaptation and formulating generalised recommendations for how to address them. To overcome this challenge, Biesbroek et al. (2011) sought to group barriers to adaptation into thematic clusters. They then surveyed adaptation stakeholders on the relative importance of the identified clusters, which resulted in the identification of the seven groups of barriers described in the table 9-1.

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| **Conflicting timescales:** Climate change is a long-term process, and while the detrimental effects of many of its impacts are already being experienced, the most significant impacts are expected to be incurred years, if not decades, in the future. This puts climate change adaptation at odds with the typical dynamics and short-term focus of most policy processes in modern democracies. Indeed, other issues and impacts seem more urgent and less complex and are expected sooner and, therefore, appear more certain, and countermeasures addressing them will produce more visible short-term results. |
| **Substantive, strategic and institutional uncertainty:** Three types of uncertainty described in the literature are key to society's handling of climate change, and some of the most reported barriers to adaptation are associated with these uncertainties. Substantive uncertainties about exact climate change impacts and the quality and reliability of data. Strategic uncertainties caused by a lack of understanding of strategies that guide other actors' behaviour in decision-making processes. Lastly, institutional uncertainties caused by a lack of knowledge of the institutional background guiding other actors' behaviour in decision-making processes. |
| **Institutional barriers:** Two opposite types of institutional barriers to adaptation exist. First, a lack of institutions enabling or facilitating adaptation to climate change may lead to an institutional void. Second, too many institutions related to adaptation may impede adaptation progress because competing institutions can create conflict and uncertainty about exact goals and prioritisation, as well as about the allocation of tasks and responsibilities. |
| **Fragmentation:** A common issue in policy design and implementation, fragmentation refers to an insufficient exchange and coordination between relevant actors and institutions from different sectors and different administrative levels, as well as between governmental and non-governmental actors. Many problems can arise due to fragmentation. For example, adaptation measures taken by separate institutions may counteract each other, leading to maladaptation due to a lack of coordination. Furthermore, relevant knowledge may be unavailable to the actors who need it because knowledge diffusion is impeded by fragmentation. The fact that climate change is both a multi-sectoral and a multi-level issue exacerbates these problems. |
| **Lack of awareness and communication:** One of the most important barriers to climate change adaptation is that many people are still unaware of or in denial about the gravity and immediacy of climate change and its impacts. Lack of communication on climate change adaptation between science, politics and society and the lack of awareness of adaptation issues resulting therefrom constitute the root causes of many barriers to adaptation. |
| **Motives and willingness to act:** This cluster of barriers includes all obstacles related to the psychological aspects of decision-making processes, encompassing factors such as attitudes, beliefs, |

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| norms and values and the role they play in determining individuals' level of motivation to engage in adaptation activities. One of the most prominent examples of the relevance of such factors is the willingness to act generated by recent extreme events. |
| **Resources:** Lastly, a lack of committed adaptation resources is often reported as a barrier to climate change adaptation. This includes financial and human resources but also informational, technical and natural resources. This group of barriers is closely related to adaptive capacity as it includes many factors commonly thought to be key determinants of adaptive capacity. |

**Table 9-1: Clusters of barriers to adaptation (adapted from Biesbroek et al., 2011).**

These thematic clusters provide a rudimentary framework that assists in the classification and cross-case comparison of barriers to adaptation. They also showcase the breadth of different barriers to adaptation and allow initial insights into the causal mechanisms underlying those barriers. Of course, as with the determinants of adaptive capacity, these clusters of barriers to adaptation are highly interconnected. As examples, strategic and institutional uncertainties are often caused or at least exacerbated by fragmentation between relevant actors and institutions, while conflicting timescales and lack of awareness are major factors impeding willingness to act. As another example, the allocation of resources is determined by political prioritisation, which is directly connected to motives and willingness to act. Nevertheless, clustering reported barriers into these thematic groups allowed Biesbroek et al. (2011) to analyse the relative importance of different barriers according to a survey of adaptation experts. They found that conflicting timescales were, on average, considered the most important barriers, with concrete examples including the lack of a sense of urgency and the short-term focus of most modern politics. Another important barrier these authors identified was the lack of financial funds to implement climate change adaptation initiatives, which is, of course, directly related to the failure to prioritise climate change adaptation due to the issues of conflicting timescales as noted (Biesbroek et al., 2011).

Interestingly, the local actors surveyed generally judged barriers to climate change adaptation to be more severe than their national counterparts considered them. Policymakers at local levels especially judged the lack of higher-level laws and regulations to mandate and enforce the development and implementation of adaptation measures to be a much more important barrier than national level policymakers deemed it. A lack of financial resources, too, was perceived as a much more problematic barrier by actors at the local level than their higher level counterparts (Biesbroek et al., 2011). As discussed in the section on multi-level governance, the local level is generally expected to take on the design and implementation of concrete adaptation measures, while the national level is expected to take care of awareness raising measures, facilitate stakeholder exchanges and provide strategic guidance, scientific background information, expert advice and funding. This distribution of

responsibilities, combined with the disparate access to resources, results in very different barriers being most relevant at the local level than at superordinate administrative levels.

Thus, the relevance of different barriers to adaptation depends on the context of the case. The same factor that constitutes a barrier to climate change adaptation in one case may be beneficial in another. Accordingly, newer studies on barriers to adaptation to climate change stress the importance of understanding the specific contexts in which certain factors constitute barriers in some cases while being beneficial in others. Understanding why and how barriers arise will improve our ability to overcome or even pre-empt them (Eisenack et al., 2014, 2015).

Some argue that the study of barriers to climate change adaptation suffers from a conceptual problem similar to the one involved in the study of adaptive capacity: it is based on a functionalist understanding of how policy implementation processes work, which assumes that policy changes will automatically emerge to address newly arising issues as long as any obstacles impeding such changes are removed (Biesbroek et al., 2015; Wellstead et al., 2018). However, contemparary studies of policy design and implementation processes are usually based on much more nuanced conceptualisations of the way policy outcomes are achieved (Stone, 2011; Torfing et al., 2012). Policy responses do not simply arise organically in response to drivers. Their design and implementation is contingent on a series of decision-making processes that are affected by political power struggles, the relative influence of various special interest groups and the social learning, policy innovation and policy diffusion processes (Jordan & Huitema, 2014). Thus, Biesbroek et al. (2015) asserted that the compilation of barriers to climate change adaptation propagates a simplistic view of how policy decision-making processes work that does little to improve our understanding of the way climate change adaptation works in practice, the causal mechanisms that serve as the root cause of the adaptation implementation gap and ways to close this gap.

## 10 Theoretical framework and key concepts

This dissertation takes a qualitative approach to examining adaptation. By conducting case studies on adaptation, I aimed to reveal the casual mechanisms underlying the adaptation implementation gap. As this dissertation is ultimately concerned with how to overcome this adaptation implementation gap in Switzerland, I was interested in both barriers to adaptation as well as important success factors – or opportunities – for adaptation (Lonsdale et al., 2017; Simoes et al., 2017; Uittenbroek et al., 2013). Often, barriers and opportunities for adaptation are two sides of the same coin. The most important success factors for a specific adaptation measure may be what allows its most relevant barriers to be overcome. In any case, the complete context in which these factors become important must be understood so that those lessons can be optimally transferred and applied to other instances of climate change adaptation.

### 10.1 Policy implementation

Originally, policy implementation research was primarily concerned with explaining observed implementation deficits - discrepancies between the declared goals of policy outputs and their observed outcomes (Knoepfel et al., 2011; Pressman & Wildavsky, 1973). Many more recent articles primarily interested in explaining why policies fail or succeed still implicitly or explicitly understand policy implementation to simply mean the processes through which policy outputs result in or fail to result in desired outcomes (Dupuis & Knoepfel, 2013; Runhaar et al., 2018). While my research interest also concerns reasons for the adaptation implementation gap in Switzerland, my definition of policy implementation encompasses broader processes, guided by the multi-level governance framework. The broadest conceptualisations define implementation as the sum of all activities and processes involved in the execution of any legislation once it has passed the parliamentary stage (Knoepfel et al., 2011). However, Swiss adaptation policy at the federal level is primarily guided by the Swiss national adaptation strategy, which itself is not directly based on any particular piece of legislation but instead was drafted upon the order of the federal executive. Additionally, this definition fails to completely account for how policies may diffuse across administrative levels or how similar policies and measures may arise simultaneously at different scales independently of any concrete laws to be implemented. For example, at the local level, many adaptation measures arise spontaneously in response to climate change impacts without specific laws to guide them.

The adaptation implementation gap observed in Switzerland that constitutes the primary research object of this dissertation has two key dimensions. The first is the implementation deficit of the Swiss national adaptation strategy in the classical sense on the horizontal axis at the federal level. The

horizontal integration of adaptation goals into different sectoral policies at the federal level achieved by the Swiss national adaptation strategy has produced adaptation outputs, but significant outcomes have so far only been achieved in sectors in which adaptation goals were coherent with existing sectoral policy goals (Widmer, 2018). The second dimension relates to the adaptation implementation gap in the multi-level governance sense. Municipalities are expected to take on the lion's share of the work for the design and implementation of concrete adaptation measures. However, Swiss federal adaptation policies thus far have failed to result in comprehensive adaptation efforts at the local level, and climate change adaptation has barely entered local policy agendas in most municipalities (Braunschweiger et al., 2018; Kruse et al., 2009). At the cantonal level, many cantons have yet to ratify cantonal adaptation strategies or to clearly assign adaptation responsibilities within the cantonal authorities. As the sub-national levels are expected to play an instrumental role in climate change adaptation governance, this thesis focuses on this second dimension of the adaptation implementation gap in Switzerland relating to the adaptation implementation gap in the multi-level governance sense. Thus, in conducting my research, I was primarily interested in the ways adaptation policies and measures were conceived and executed at different administrative levels and what role existing adaptation policies at superordinate levels play therein. Accordingly, I defined climate adaptation policy implementation as the sum of all activities and processes through which adaptation policies produce outputs across administrative levels and different sectors.

Figure 10-1 illustrates this understanding of adaptation policy implementation, depicting how adaptation policies and strategies are implemented through policies and measures in different policy sectors as well as at different administrative levels and how policies may diffuse across levels and sectors. The figure also illustrates the influence climate change impacts and international agreements may have on the implementation of climate change adaptation policies at different administrative levels.

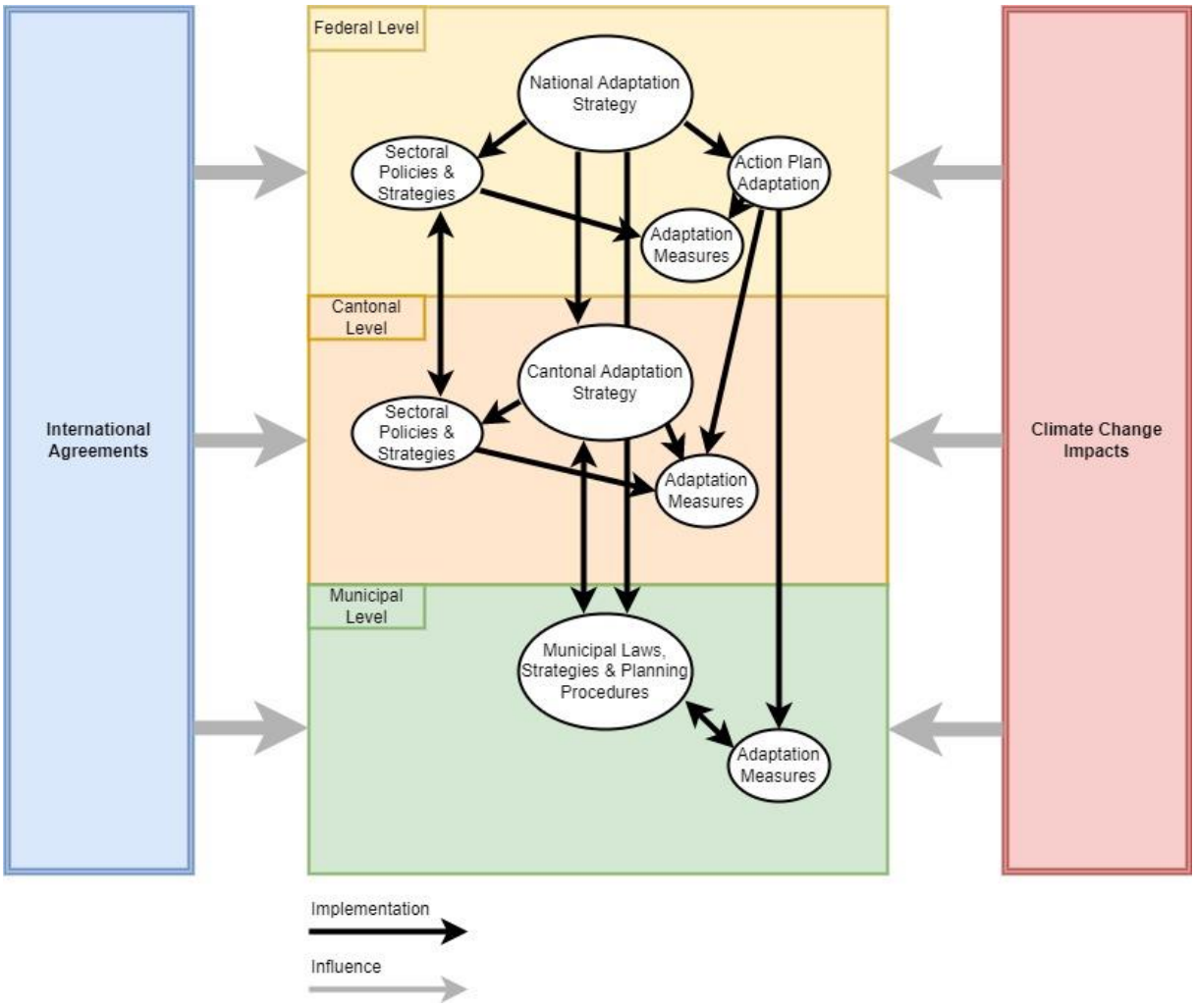


**Figure 10-1: Climate change adaptation policy implementation in Switzerland**

## 10.2 Multi-level governance

The impacts of climate change vary extensively and affect a multitude of policy issues: a short list of examples includes water management, natural hazard management, energy production and distribution, human health and well-being, animal health, forest management, agriculture, and biodiversity, as well as housing and spatial planning. Thus, adaptation to climate change is a multi-sectoral challenge. It is also a multi-level challenge as climate impacts vary across regional and local levels, creating unique adaptation needs (Bauer & Steurer, 2014; Dewulf et al., 2015). As such, uniform approaches to climate change adaptation dictated by the national or even supranational level are unlikely to produce optimal results across all sectors and regions. Instead, municipalities and other governmental and non-governmental actors at the sub-national level are expected to assume a frontrunner role in identifying and prioritising local adaptation needs and in designing and implementing adaptation measures to address those needs (Galarraga et al., 2011; Keskitalo, 2010).

Meanwhile, the national and regional levels are expected to develop adaptation policies, strategies and guidelines, to raise awareness of adaptation issues and to provide scientific information and expertise, as well as funding, when necessary (Bauer & Steurer, 2014; Keskitalo, 2010; Kruse & Pütz, 2014). Additionally, since climate change adaptation also concerns private businesses and individuals, superordinate governmental actors are expected to facilitate exchanges with and between non-state actors (Cimato & Mullan, 2010). Moreover, as climate change is an issue of global proportions, a multitude of international organisations and agreements exist that seek to coordinate and promote climate change mitigation and adaptation policies and measures within their member states: National and sub-national climate change adaptation policy is further mandated, guided and informed by any of these international agreements into which the country in question has entered.

In summary, climate change adaptation is, by nature, a multi-level endeavour requiring coordination between multiple policy sectors and administrative levels, as well as between governmental and non-governmental actors (Amundsen et al., 2010; Bauer & Steurer, 2014; Corfee-Morlot et al., 2011; Dewulf et al., 2015; Keskitalo, 2004). Thus, the multi-level governance framework constitutes the overarching conceptual framework of this thesis. Coined by Hooghe et al. (2001), the multi-level governance framework departs from the traditional nation-state centric view of governance (Hooghe et al., 2001; Marks et al., 1996). Instead, it focuses on how political authority is dispersed vertically to other administrative levels and horizontally to non-state actors (Bache & Flinders, 2004). The multi-level governance framework and the closely related polycentric governance framework emphasise the shift of political power and decision-making from the national level to the superordinate international level, to the subordinate regional and local levels and to non-governmental actors. This framework highlights the need to understand how actors from different government levels, as well as non-governmental actors, interact, coordinate their actions, cooperate and learn from one another. Also emphasised is understanding how policies diffuse horizontally across political sectors in addition to understanding how they diffuse vertically between levels, both top-down and bottom-up. With its focus on the way political power is divided across scales, how these scales interact and how decision-making processes and policies originating at one level influence and diffuse to other levels, the multi-level governance framework is well-suited for analysing climate change adaptation governance. Additionally, the federal political system of Switzerland delegates much political power and responsibilities to the municipal and cantonal levels and includes institutionalised mechanisms, such as the consultation process, which incorporates non-profit organisations, special interest groups, trade associations and/or other non-governmental actors into political decision-making processes (Ladner, 2010). Hence, both the Swiss political system and the issue of climate change adaptation are concordant with the key assumptions and focal lenses of the multi-level governance framework.

### 10.3 Mainstreaming climate change adaptation

Mirroring the variety of climate change impacts, myriad climate change adaptation options exist. Climate change adaptation policies and measures can differ in many regards: Which specific climate change impacts are driving the adoption of the policy or measure? What forms do the adaptation measures take? Are they technological, financial, institutional, or behavioural in nature? Are they aimed at the local, regional, national, or international level? Do they take place autonomously – for example, as largely unintended side effects of activities not directly related to climate change adaptation – or are they planned? Are measures taken in anticipation of climate change impacts prior to their realisation, concurrently as impacts take place or in reaction to impacts after the fact? Do they aim to achieve incremental or transformative changes? (Biagini et al., 2014; Smit et al., 2000). The variety of climate change impacts and corresponding climate change adaptation measures and their distribution across different political sectors complicates climate change adaptation governance. With climate change impacts affecting matters ranging from public health and energy production to agriculture and water management, which government institutions should be responsible for climate change adaptation? Many European countries, including Switzerland, approach this dilemma by mainstreaming adaptation goals into the existing sectoral policies and tasks of all affected governmental sectors (Bauer et al., 2012; Bauer & Steurer, 2015; Biesbroek et al., 2010; Widmer, 2018).

Although definitions of the concept vary, climate change adaptation mainstreaming, which is closely related to environmental policy integration, is commonly understood as the integration of adaptation goals into the guiding policies and day-to-day work of different government sectors. A common point of contention on the specific definition is the difference between the vertical and horizontal integration of climate change adaptation goals. Many definitions of mainstreaming exclusively pertain to the horizontal integration of adaptation goals across sectoral policies, while others define mainstreaming as the integration of adaptation goals into any existing policies. Another important element of the definition of mainstreaming is prioritisation. Some definitions of environmental policy integration state that environmental policy objectives need to take priority over any other objectives for true integration to be achieved (Lafferty & Hovden, 2003). However, working definitions of climate change adaptation mainstreaming rarely include such high standards for prioritisation. This may well be a weakness of mainstreaming, both conceptually and in practice, as Widmer (2018) showed that, although climate change adaptation goals had been mainstreamed into many Swiss sectoral policies at the national level, actual implementation was sparse. Conceptually, the vagueness with respect to expected and desired outcomes and to strategies for implementing climate change adaptation

mainstreaming has translated into sparse empirical results on what exactly climate change adaptation mainstreaming looks like in practice and how effective it really is.

Nevertheless, climate change adaptation mainstreaming does offer many advantages, such as improving the effectiveness and efficiency of public policy by combining objectives. Additionally, mainstreaming enables climate change adaptation goals to be achieved while keeping the need for additional financial or personnel resources at a minimum and ensures the long-term sustainability of climate change adaptation measures (Adelle & Russel, 2013; Kok & de Coninck, 2007; Uittenbroek et al., 2013). Consequently, the European Union (EU) white paper on adaptation recommends climate change adaptation mainstreaming as a method for implementing climate change adaptation (COM, 2009). Mainstreaming is the climate change adaptation approach employed by most European countries (Bauer et al., 2012), and many climate change adaptation policies and measures that have been implemented successfully represent extensions of existing policies (Eisenack et al., 2014). Thus, mainstreaming is one of the most promising approaches for the implementation of climate change adaptation. As such, investigating exactly what mainstreaming entails in a multi-level governance system is crucial. Different mainstreaming strategies have distinct advantages and disadvantages, and the horizontal mainstreaming of adaptation goals across sectors differs from the vertical mainstreaming of adaptation goals into cantonal and local policies and measures. Thus, I examined the different mainstreaming strategies employed in Swiss climate change adaptation governance and the role they play in the successful implementation of climate change adaptation policies and measures.

## 11 Research Design

Presented in this section are my case selection and my reasons for focusing on the case of Switzerland, along with explanations of the various quantitative and qualitative scientific methods employed throughout this research to gain insights into Swiss climate change adaptation governance. This includes the data collection process, my definition and operationalisation of climate change adaptation, the analytical methods used to process the data and the reasons for choosing these approaches.

The dissertation combines a case study approach with a comprehensive mapping of the actors, policies and measures involved in the implementation of the Swiss National Adaptation strategy. This governance mapping created an overarching outline of how the Swiss climate change adaptation strategy and action plan have been implemented and which actors played key roles in said implementation. The mapping served as an important basis for the selection of interesting cases among Swiss climate change adaptation projects and policy processes for in-depth case studies. It also provided the data basis for the social network analysis I employed to identify key bridging actors in Swiss climate change adaptation governance. Case studies provide in-depth information on processes and phenomena from multiple sources and perspectives. Thus, they are well-suited for explorative studies aiming to understand causal mechanisms and the role and relevance of contextual factors.

### 11.1 The Swiss case

My thesis concerns the empirical case of Switzerland. Switzerland is an interesting case for several reasons: one is that average temperature increases due to climate change in the Alpine space are twice as high as the global average (Köllner et al., 2017). These rising temperatures have had severe effects on Alpine ecosystems and landscapes by melting permafrost and glaciers. Higher temperatures can increase the spread of invasive species and disease vectors and can have a dire impact on human health. The Alpine regions are also subject to many natural hazards, the intensity and frequency of which is being exacerbated by the impacts of climate change (Brönnimann et al., 2014; Köllner et al., 2017). Additionally, Switzerland is a very wealthy country that has made international commitments to invest in climate change adaptation by signing the Paris Agreement. Moreover, the federalist nature of the Swiss political system (Bogdanor, 1988; Church & Dardanelli, 2005) promotes fostering the multi-level coordination necessary to address a multi-level issue such as adaptation to climate change. Thus, the country should have both ample means and motivation to take measures to adapt to climate change.

Nevertheless, recent research shows evidence of a climate change adaptation implementation gap in Switzerland. The adaptation strategy of the federal council, as well as the corresponding action plan, primarily aim to coordinate the adaptation endeavours of different governmental sectors by mainstreaming adaptation goals into existing sectoral policies and strategies (Widmer, 2018). However, Widmer (2018) reported that 'even though adaptation has been included in the sectoral strategies and action plans for natural hazards, forestry, biodiversity, and agriculture, coordination remains absent'. Worse yet, as he explained, 'a major gap seems to exist regarding the implementation of new instruments. So far, ideas are merely outlined on a conceptual level, refer to research projects or to […] pilot projects' (Widmer, 2018, p. 77). Dupuis and Knoepfel (2013) similarly found that Swiss adaptation policy at the national level mainly had an agenda-setting effect, demonstrating little influence on the implementation of impactful adaptation measures beyond the adaptation pilot programme.

The legal basis for climate change adaptation in Switzerland is the CO2-law, which mandates the cantons to regularly inform the Federal Office for the Environment (FOEN) about their climate change adaptation progress. While this technically delegates responsibility for climate change adaptation to the cantons, the law does not establish any specific adaptation goals to be reached, nor does it dictate specific adaptation measures to be taken, nor regulate the dedication of funds to climate change adaptation. In consequence, the extent of climate change adaptation engagement to which cantons commit is largely up to them, and many have yet to even publish formal cantonal adaptation policies or strategies. Meanwhile, the municipal level is expected to play a key role in implementing concrete climate change adaptation measures (Fünfgeld, 2015; Nordgren et al., 2016). Most climate change adaptation measures must take place at the local level because climate change impacts and the associated risks vary according to sociocultural, geographical, and topographical context (Bauer & Steurer, 2015; Betsill & Bulkeley, 2006; Sarker et al., 2020). Despite their important prospective role, most Swiss municipalities have yet to take any climate change adaptation measures. Exceptions are rare and mostly limited to larger, wealthy cities, Alpine municipalities with high exposure to climate change impacts and risks and municipalities participating in adaptation pilot projects financed by federal agencies.

### 11.2 Defining and measuring climate change adaptation

A key issue for most research concerned with the governance of climate change adaptation is the dependant variable problem. Climate change adaptation is difficult to define and even more difficult to measure. The IPCC's (2022) working definition of climate change adaptation is initiatives intended

to reduce climate risks, to reduce vulnerability to climate change impacts and to take advantage of opportunities afforded by climate change impacts. However, climate change impacts come in many varieties. Consequently, many policies and measures that reduce vulnerability to climate change impacts have spillover effects or may even be primarily aimed at other goals, such as improving biodiversity, reducing risks caused by natural hazards or improving quality of life in urban environments, to name only a few examples. Generally, this situation constitutes a big advantage for climate change adaptation. For example, climate change adaptation policies and measures usually have positive spillover effects on other policy fields, making political support and funding for these initiatives easier to secure. The spillover effects and alignment with other goals also explain one of the primary reasons that mainstreaming climate change adaptation goals into existing sectoral work is the most popular approach chosen by OECD countries to implement climate change adaptation. However, this also means that many policies and measures that do not specifically aim towards climate change adaptation, nevertheless, have spillover effects that reduce climate risks or vulnerability to climate change impacts. Such policies and measures may not be declared as climate change adaptation initiatives, nor were they necessarily motivated by a need or want to adapt to climate change. Furthermore, the actors responsible for their design and implementation may not even be aware of the effects these policies and measures have on climate change risks and vulnerability to its impacts. Some authors call this type of adaptation "unintentional" or "hidden" adaptation (Grüneis et al., 2016). Many such hidden adaptation activities primarily serve as natural hazard management or disaster risk reduction measures, often pursuing technological solutions, such as the construction of dams and protective walls and barriers. The question remains whether such hidden adaptation activities should be considered when analysing the governance of climate change adaptation and, especially, barriers to and drivers of climate change adaptation.

Within the scope of this dissertation, I deal with this question in two ways: the climate change adaptation governance mapping and the case studies and social network data derived therefrom, for which only policies and measures explicitly motivated by and specifically declared as targeting climate change adaptation were considered. I selected this approach for a few reasons. First, the mapping was meant to provide as comprehensive a picture of Swiss climate change adaptation governance as possible; expanding the working definition of climate change adaptation to include hidden adaptation policies and measures was not feasible due to budgetary and time constraints. Second, one of my primary research interests explicitly concerned how climate change adaptation policies and measures were being implemented in Switzerland at multiple administrative levels. I focused on such policies to research the causal mechanisms underlying the Swiss adaptation implementation gap. Similarly, key barriers and opportunities for the implementation of climate change adaptation policies and measures may vary drastically between explicit climate change adaptation and hidden, unintentional adaptation.

Finally, this research was centred on key actors in Swiss climate change adaptation governance and the role they play by fostering coordination and cooperation and disseminating information to other actors relevant to climate change adaptation. As such, analysing data that included actors who had only been involved in hidden adaptation policies and measures would not have been prudent, as such actors likely lacked interest in coordinating climate change adaptation measures and in disseminating or receiving information on climate change adaptation unless they were also involved in explicit climate change adaptation.

However, I chose a different approach to identify factors or combinations of factors that determined whether municipalities engaged in climate change adaptation for my case studies on climate change adaptation in Alpine municipalities. Regarding these cases, I considered the occurrence of unintentional or hidden adaptation an example of local adaptation as long as it took place in response to climate change impacts, regardless of whether the policies and measures were explicitly designated and understood by the municipalities in question as targeting climate change adaptation. As I began these case studies, I quickly realised that climate change adaptation in these smaller municipalities – if it took place at all – was commonly focused on specific climate risks. Measures usually aimed to reduce specific risks and were rarely based on superordinate municipal climate change adaptation policies or strategies that addressed the issue holistically. As such, I determined that, for these case studies, the most logical approach was to base my working definition of climate change adaptation policies and measures on whether they specifically addressed climate risks rather than whether they had been officially designated as targeting climate change adaptation.

Defining and measuring climate change adaptation is further complicated by the difficulty of operationalising the outcomes of climate change adaptation policies and measures. The outcomes of climate change mitigation policies and measures are usually operationalised based on the total CO2 equivalent reduction achieved. However, no such catch-all unit of measure exists for climate change adaptation. With that in mind, when analysing barriers to and drivers of climate change adaptation implementation, I generally considered climate change adaptation outputs rather than outcomes as the dependant variable.

### 11.3 Case selection and data collection

I began the data collection process by attending an expert workshop on climate change adaptation in the Alpine space. The workshop included climate change policy researchers from several Alpine countries, as well as members of the climate change departments of various national agencies. The workshop was intended to identify the most important governmental climate change adaptation policies, strategies, action plans and measures at the national and regional level from among those of

all Alpine countries, including Switzerland, as well as the actors involved in their design and implementation. This first expert assessment event served as the basis for extensive document research. After consulting all available documentation on the policies, strategies, action plans and measures identified at the workshop, including progress reports, final reports and evaluations, I gathered additional data on any subsequent measures taken to implement those policies and measures, as well as on all the actors involved in the related processes. Thus, the first climate change adaptation governance mapping was developed.

During this mapping process, the pilot programme adaptation emerged as the most prominent example of a concrete, on-the-ground measure among the climate change adaptation measures contained in the Swiss national action plan adaptation. The first phase of the pilot programme adaptation had already been fully implemented when I began my dissertation. As such, I selected both the pilot programme itself, as well as four climate change adaptation projects funded by it, as case studies. Three out of these four pilot projects were implemented in the canton of Grisons and were embedded within the Cantonal Climate Strategy Grisons and co-financed by cantonal agencies. Thus, I conducted an additional case study on the Cantonal Climate Strategy Grisons to analyse the implementation of climate change adaptation at the cantonal level. This also allowed me to assess the multi-level cooperation between pilot project teams, their federal sponsors and their cantonal sponsors in more detail. The fourth pilot project case study concerned climate change adaptation in the city of Sion. This detailed analysis of urban climate change adaptation was supplemented by two further case studies in the cities of Zurich and Biel that were unaffiliated with the pilot programme adaptation.

The pilot programme adaptation was co-financed by several federal agencies involved in the implementation of the national action plan adaptation and coordinated by the FOEN. It aimed to promote climate change adaptation at the regional and local level by funding concrete projects that could serve as good practice examples. Thus, this selection of case studies allowed for insights into the implementation of Swiss climate change adaptation at the national, cantonal and local level. The focus of the case study approach on analysing processes from multiple perspectives was also appropriate for assessing a multi-level process, such as the pilot programme adaptation. Thus, I conducted a total of eight case studies: four on specific pilot projects, two on urban adaptation in the cities of Zurich and Biel, one on the pilot programme adaptation itself and one on the Cantonal Climate Strategy Grisons. To supplement the data on these eight cases that I had gathered through document analyses, I conducted 24 semi-structured interviews with stakeholders from federal, cantonal and local governmental agencies, as well as employees of private research and consulting agencies that were involved in the design and implementation of specific pilot projects. Some of the interviewees were

involved in and had input on multiple cases. As such, four interviews were relevant to each case study, ensuring that different perspectives from representatives of different scales of governance were included for each case.

The interview results were also used to supplement the climate change adaptation governance mapping with any new information on relevant climate change adaptation policies, measures and actors. Any newly revealed relevant policies and measures were then also included in further document analyses, thus ensuring the comprehensiveness of the mapping. This data collection phase took place from October 2017 to June 2018. The final mapping includes 25 climate change adaptation policies, 109 measures and 135 actors, including federal, cantonal and local agencies, trade associations, nature conservation organisations, research institutions and private businesses.

My three case studies on climate change adaptation in Sion, Zurich and Biel focused predominantly on urban climate change adaptation in larger cities. To develop a comprehensive understanding of local climate change adaptation in Switzerland, smaller, more rural municipalities must also be considered, as they often have very different access to human and financial resources than larger cities, as well as very different political priorities. Thus, for the final part of the dissertation that focuses on identifying drivers of local climate change adaptation, I conducted another 21 case studies on alpine municipalities exposed to relatively high risk by natural hazards and disproportionately affected by climate change impacts aggravating said natural hazards or introducing new risks. Most of these 21 municipalities are relatively small villages with less than 3,000 inhabitants. I selected potentially interesting cases based on several criteria. First, I was interested specifically in municipalities exposed to different natural hazards: mudflow, avalanches, rockfall and floodings. These hazards are typical for Alpine regions and threaten to grow more frequent and severe due to the impacts of climate change (BAFU, 2012; EEA, 2009; Köllner et al., 2017). I consulted the cantonal natural hazard risk maps to select municipalities with comparatively high exposure to such risks. For information on climate change risk perception, I worked with survey data collected by the Swiss Broadcasting Corporation (SRG SSR) and the Link Institute in 2017 and calibrated for qualitative comparative analysis following Wieser (2019). Unfortunately, these survey data included a significant number of questionnaires from only the more populous Alpine cantons of Bern, Grisons and Valais, thereby restricting my selection of Alpine municipalities to these three cantons.

To identify the factors that determined whether a municipality engaged in climate change adaptation, I wanted my case studies to include some variation regarding my outcome variable. As such, I consulted my climate change adaptation governance mapping and performed some additional desktop research

on more recent climate change adaptation projects to identify Alpine municipalities in Bern, Grisons or Valais that were involved in prominent local climate change adaptation projects and measures. I supplemented this selection of municipalities through five open-ended interviews with experts on Swiss natural hazard management from the FOEN, the cantonal agencies for natural hazard management and the Federal Research Institute WSL. To ensure the intended variation of the outcome variable, I asked them about municipalities with high exposure to climate change impacts that had so far neglected to take any steps to reduce their vulnerability to climate change. Based on their assessment and my criteria as noted, I settled on 29 interesting municipalities to serve as case studies. Out of these 29 municipalities, 8 were eliminated from the sample because they either denied or never responded to my interview requests; I conducted semi-structured interviews with representatives of the local executive or the local agencies responsible for natural hazard management from the remaining 21 municipalities. The interview discussions addressed recent extreme events, how local natural hazard management is organised and what measures it takes, how local natural hazards and climate change impacts are perceived by the populace, any steps taken by the municipality to adapt to climate change and the political composition of the local executive. The interview data were supplemented by several additional sources: In addition to the SRG SSR and Link Institute survey data, as well as the cantonal risk maps, I consulted the FOEN extreme events database StorMe to corroborate the interview data on recent extreme events, and I gathered election data compiled by the Federal Statistical Office (FSO) on the most recent (2019) election of the Swiss national parliament. These election data served as an additional indicator of the political leanings and sympathies of the residents of the municipalities in my sample.

### 11.4 Methods of analysis

I employed a mix of quantitative and qualitative methods to supplement and enhance each other for this research. The mapping of Switzerland's climate change adaptation governance was first used as a basis for the selection of case studies that addressed barriers to and success factors that facilitate climate change adaptation implementation, as well as climate change adaptation mainstreaming. The information gained through these case studies was, in turn, used to supplement the mapping, making it more comprehensive. The case studies were based on a combination of document analyses and analysis of data gleaned from the semi-structured interviews, which were analysed using a qualitative content analysis (Mayring, 2000; Mayring & Brunner, 2007; Mayring & June, 2014). The interviews were coded according to the topics discussed and according to whether they pertained to different mainstreaming strategies, as well as to barriers and success factors for climate change adaptation. These data served as the empirical basis for my analysis of how climate change adaptation policies and

measures were being implemented across multiple administrative levels in Switzerland and of the influential factors that either hindered or promoted these implementation processes.

The climate change adaptation governance mapping linked policies and measures to the actors involved in their design, financing and implementation. As such, it was well-suited to serve as the data basis for a two-mode network analysis because I was able to infer connections between actors based on their co-participation in the same policies or measures. Thus, I employed a social network analysis to identify actors who played especially important roles in Swiss climate change adaptation governance, whether by taking on central roles to promote coordination and disseminating information across their network, or by connecting a diverse pool of actors with each other, thus increasing the heterogeneity of the network and its access to new information. Hence, employing a social network analysis and the metric associated with it allowed me to quantify the relative importance of different actors represented in the climate change adaptation governance mapping.

The research described in this dissertation was further intended to identify factors or combinations of factors that determined whether municipalities engaged in climate change adaptation. I investigated this topic based on 21 case studies of Alpine municipalities with high exposure to natural hazards and climate risks. To analyse these case studies, I employed a qualitative comparative analysis (QCA). A QCA aims to identify different conditions, or combinations of conditions, that are necessary and/or sufficient for a specific outcome to occur. I chose a QCA for two main reasons. First, the QCA proposes that different constellations of conditions may constitute equifinal paths to specific outcomes. This concept was in line with my own expectation that different paths or reasons may drive a municipality towards engaging in climate change adaptation. Secondly, a QCA is well-suited for the analysis of a medium number of cases and, thus, was a good fit for this study. As the case studies were primarily based on semi-structured interviews, I once again employed a qualitative content analysis to code the conditions I expected to be relevant. I then performed the QCA to test for necessary and sufficient conditions for both the outcome (the municipality engaged in climate change adaptation) and the non-outcome (the municipality did not engage in climate change adaptation) separately.

## 12 Outlook to the three papers

My research interest and the overarching research question for this doctoral study, as presented in the introduction, were addressed in three scientific papers. This chapter presents a short outlook on these papers, which are presented in full in the final chapters. The three papers have been published in or submitted for publication to different academic journals with a thematic focus on environmental policy and governance research.

The first paper, 'Climate Adaptation in Practice: How Mainstreaming Strategies Matter for Policy Integration' (Braunschweiger & Pütz, 2021), was published in *Environmental Policy and Governance*. This article presents an in-depth analysis of the various strategies that are being employed to mainstream the goals of the Swiss national adaptation strategy across multiple policy sectors and administrative levels. Some of the most successful approaches as well as some of the most pertinent barriers to these processes are discussed in the article. This first paper focuses on the process of climate change adaptation implementation, examining the approaches chosen by different governmental agencies and non-governmental actors at multiple administrative levels in Switzerland to implement climate change adaptation policies and measures. Moreover, the article presents a critical examination of common barriers to and success factors for climate change adaptation implementation and compares how these influential factors have been addressed across different cases. The results paint a picture of adaptation stakeholders across scales employing soft power, cooperative and persuasive measures to achieve important adaptation goals through win-win measures and by piggybacking adaptation goals onto existing projects. However, the lack of clear legal climate change adaptation mandates and the failure to dedicate funds to adaptation implementation leaves important conflicts of interest between climate change adaptation and other objectives largely unaddressed; moreover, it keeps local climate change adaptation overly reliant on the personal motivation of local stakeholders.

The second paper, 'Cross-Scale Collaboration for Adaptation to Climate Change - A Two-Mode Network Analysis of Bridging Actors in Switzerland' (Braunschweiger, 2022), was published by *Regional Environmental Change*. This paper discusses the importance of social networks in the governance of climate change adaptation and their role in promoting related coordination and cooperation across scales. A social network analysis was applied to identify key bridging actors in Swiss climate change adaptation governance. The article examines the ability of these bridging actors to connect important actors across sectoral barriers and administrative levels. In addition, the implications of these findings for the state of Swiss climate change adaptation governance as a whole are outlined. While the first paper demonstrates the importance of actors and their motivation and objectives for implementing climate change adaptation, the second paper takes a more actor-centric approach. Reasoning that one

path towards supporting the implementation of climate change adaptation must be to support the actors who play key roles in these processes, the second paper aimed to identify such actors. The article also explains how and why these actors came to fulfil these roles and what implications these findings have for climate change adaptation governance in Switzerland and as a whole.

The third and final paper, 'What Drives Local Climate Change Adaptation? A Qualitative Comparative Analysis', which I co-authored, has been submitted for publication to the journal *Environmental Science and Policy* and is currently under review. This work presents an examination of the state of climate change adaptation in smaller Alpine Swiss municipalities that are heavily exposed to different natural hazards and, thus, strongly affected by the impacts of climate change on these hazards. This article describes the QCA employed to identify factors or combinations of factors to explain why some of these municipalities were highly engaged in climate change adaptation, while others were mostly going about business as usual. Continuing the actor-centric approach of the second paper, the third paper shifts the focus from the implementation of the Swiss national adaptation strategy and its subsequent policies and measures to independently arising local adaptation processes. The article addresses whether municipalities engaged in climate change adaptation and, if not, why, zeroing in on the deeper reasons behind the motivations of local stakeholders that had been identified as influential factors in the first paper.

Together, the three papers cover the integration of nationally formulated adaptation goals into regional and local policies, the roles different adaptation actors play in overcoming boundaries and organising cross-sectoral and multi-level cooperation and, finally, the factors that drive adaptation action on the local level. These articles contribute to our knowledge on the current practice of climate change adaptation in Switzerland and similar countries and illuminate the reasons why climate change adaptation implementation progress is lagging behind what is needed in many places, and they offer valuable recommendations for actions to address this problem.

# 13 Discussion and Conclusion

## 13.1 Key findings of the thesis and their implications

The goals of this dissertation study were as follows: (1) to take stock of how Swiss climate change adaptation is implemented in practice at multiple governmental levels, (2) to investigate which actors play key roles in Swiss climate change adaptation governance, (3) to determine what factors motivate the climate change adaptation engagement of different actors, (4) to identify important barriers and opportunities for Swiss climate change adaptation and comprehend their contextual causes and, finally, (5) to draw conclusions regarding the reasons for the climate change adaptation implementation gap in Switzerland and how it can be overcome.

This endeavour was motivated by the current climate change adaptation literature that indicates the necessary and internationally agreed upon climate change adaptation measures at the local level are not being implemented quickly and comprehensively enough, even in wealthy countries heavily affected by the impacts of climate change, such as Switzerland. Moreover, current predominant frameworks within the political science literature on climate change adaptation, such as adaptive capacity and barriers to adaptation, do not sufficiently explain how this climate change adaptation implementation gap came to be or how it can be overcome. The concept of adaptive capacity is usually operationalised based on indicators that strongly correlate to macroeconomic development or indicators that are based on household-level data, and it struggles to explain why the climate change adaptation gap persists, even in affluent nations, regions, and municipalities. The concept of barriers to climate change adaptation, while helpful, encourages an overly simplified understanding of policy processes that falls short in explaining why certain factors constitute barriers to climate change adaptation in some cases but are easily overcome in others.

Therefore, this dissertation research employed a combination of a comprehensive mapping of the actors, policies and measures involved in the design and implementation of the Swiss climate change adaptation strategy and a series of in-depth case studies of climate change adaptation measures and highly exposed municipalities to uncover the causal mechanisms underlying the implementation of climate change adaptation policies and measures in Switzerland.

The first paper supported the focus of the national adaptation strategy and action plan on implementing climate change adaptation policies through mainstreaming as the importance of different mainstreaming strategies was confirmed across multiple case studies. Swiss federal agencies have so far focused on mainstreaming climate change adaptation across sectors, cooperatively discussing and defining adaptation goals to be integrated into existing sectoral policies. However, while this approach has been successful at fostering cooperation at the federal level, the corresponding lack

of legal mandates and the lack of higher-level support for climate change adaptation at sub-national levels are responsible for some of the most important barriers to local climate change adaptation in Switzerland. Many sub-national actors, although interested in adaptation, are unsure of how to approach the topic and what climate change adaptation goals and measures to prioritise due to the lack of clear guidelines provided by higher levels, legal or otherwise. Consequently, the implementation of concrete local adaptation measures has been sporadic, limited primarily to larger cities with the personnel and financial capacity to take on such complex initiatives without significant support from superordinate levels, as well as to those few municipalities participating in the federal pilot programme. Additionally, the focus on intersectoral programmatic climate change adaptation mainstreaming has not resulted in the widespread prioritisation of adaptation. While many relevant actors are concerned with climate change adaptation, it is not their main concern. As a result, successful implementation of climate change adaptation measures has largely been limited to win-win measures.

The second paper focuses on identifying important bridging actors in Swiss climate change adaptation governance. In line with the findings of the first paper, I discovered that the most important bridging roles were almost exclusively occupied by the federal agencies involved in the design and implementation of the national adaptation strategy. However, except for the FOEN, which coordinates the pilot programme adaptation, these federal agencies, for the most part, built cross-sectoral ties rather than cross-level ties. The small number of cross-level ties maintained by the most important bridging actors in Swiss climate change adaptation governance points to the lack of directional mainstreaming that resulted from the exclusive focus of the national adaptation strategy on fostering intersectoral cooperation at the federal level. The four remaining bridging roles were occupied by two cantonal agencies from Grisons and two research institutes, respectively. Grisons took on a pioneer role in climate policy among Swiss cantons, as evidenced by the representation of two of its cantonal agencies as important bridging actors in my social network analysis of Swiss multi-level climate change adaptation governance. The cantonal climate strategy Grisons mirrored the national adaptation strategy in that it focused on fostering cross-sectoral coordination and cooperation, as reflected in the small number of cross-level ties maintained by the cantonal agencies in question. Lastly, the fact that two research institutes also took on bridging roles highlights the nature of climate change adaptation as a new policy area subject to many uncertainties but also reflects the impact of the lack of directional or regulatory climate change adaptation mainstreaming. Municipalities and cantons alike are unclear about what exactly they should adapt to and how they should do so. Thus, many of them build ties to actors specialised in researching and disseminating information. Indeed, many climate change adaptation projects realised within the last ten years still focus on developing scientific and strategic

foundations rather than on implementing climate change adaptation measures with more concrete impacts.

Finally, the third paper focuses on the local level, aiming to identify combinations of conditions that lead municipalities to engage in climate change adaptation implementation. We found that past extreme events, persistent risk exposure, the resources of local natural hazard management and local support for environmental and left-wing political parties all play important roles. However, by far the most important factor turned out to be perceived risk exposure. Perceived risk exposure is an almost necessary condition, and on its own is a sufficient condition, for local climate change adaptation. Additionally, low perceived risk exposure is a necessary condition for the absence of local climate change adaptation initiatives and is also represented in all three equifinal sufficient pathways to the absence of local climate change adaptation. These results demonstrate once again that, in the absence of comprehensive directed or regulatory mainstreaming, local climate change adaptation is highly dependent on the motivation of the local authorities, stakeholders and populace. The importance of extreme events and perceived risk suggests that perceived personal exposure may be a key factor fuelling this motivation.

At the federal level, Swiss climate change adaptation is primarily being implemented through what I call “cooperative mainstreaming”. Federal agencies cooperatively discuss climate change adaptation priorities and responsibilities, define common goals, and seek to implement these goals by integrating them into existing or newly emerging sectoral policies that guide day-to-day activities. The state of climate change adaptation at the cantonal and local levels varies. The CO2 law mandates the FOEN to coordinate Swiss climate change adaptation but otherwise largely delegates the responsibility for climate change adaptation to the cantons, yet it does not specify concrete measures to be taken or goals to be reached. In the absence of a more explicit legal mandate or more directed mainstreaming, some cantons have developed and begun implementing climate change adaptation strategies, while others have barely started the process. The canton of Grisons was the first to formulate a climate strategy that included climate change adaptation as an equivalent complement to climate change mitigation. That strategy mirrors the national adaptation strategy in that it primarily aims to foster intersectoral coordination and programmatic mainstreaming of climate change adaptation at the cantonal level. The most important instance of directed mainstreaming from the federal level observed was the pilot programme adaptation, meant to foster regional and local adaptation initiatives by providing advice and financial support. Over the course of its first and second phases, this pilot programme realised 81 projects, and it has been instrumental in the development of cross-level connections between actors interested in climate change adaptation. However, beyond the municipalities participating in pilot projects, local climate change adaptation progress has been sporadic and largely limited to big cities, as well as a few highly motivated smaller municipalities. As

the third paper describes, perceived risk exposure seems to be a major factor explaining the motivation to implement adaptation initiatives.

The lack of regulatory or directed mainstreaming is also reflected in the complete lack of institutionalised subsidies for local climate change adaptation provided by the cantons or the federal government beyond those channelled through the pilot programme adaptation. Few municipalities prioritised climate change adaptation highly enough to reallocate significant funds already committed to other purposes to finance climate change adaptation personnel and measures. Thus, climate change adaptation at the local level was usually implemented by existing governmental agencies through programmatic mainstreaming. Programmatic mainstreaming aims to integrate climate change adaptation into existing operations, projects, and programmes. This improves intersectoral coordination and coherency with climate change adaptation goals and allows the realisation of climate change adaptation goals without spending significant funds. However, this approach is also associated with significant disadvantages, especially when it is employed as the primary or even the only method to realise concrete climate change adaptation projects. Climate change adaptation will never be the top priority of existing governmental agencies with clearly defined prior responsibilities. Hence, climate change adaptation measures can only be implemented through programmatic mainstreaming if they can feasibly be combined with other goals, such as improving biodiversity or reducing natural hazard risks. This impedes the realisation of more long-term or strategic climate change adaptation measures with little obvious immediate payoffs, which, in turn, hinders the implementation of comprehensive climate change adaptation policies and may lead to maladaptation.

Climate change adaptation objectives were not comprehensively mainstreamed into Swiss laws and regulations and higher-level support for local mainstreaming initiatives remains limited to a few cases such as the pilot programme adaptation. Consequently, local climate change adaptation progress largely depends on the personal motivation of local stakeholders. Perceived risk exposure emerged as one major driver of this motivation. Closely connected to past extreme events, perceived risk exposure often revolves around a few specific risks. The ability to prioritise specific climate change adaptation measures according to the most locally relevant climate change impacts is one of the main reasons for delegating the responsibility for concrete adaptation measures to the local level. Nevertheless, with perceived risk exposure as a major motivating factor for climate change adaptation comes the risk that more subtle climate change impacts may be ignored for too long. Additionally, the single-minded focus on specific climate change impacts driven by perceived risk exposure further increases the risk that local climate change adaptation approaches will not follow a comprehensive approach.

The social network analysis revealed that the most important bridging roles in Swiss climate change adaptation governance were almost exclusively occupied by federal agencies. This represents a

departure from the findings of similar social network analyses focused on other policy fields in Switzerland, which indicated that cantonal governmental actors generally played the most important bridging roles (Angst et al., 2018). While not necessarily problematic per se, the focus of the national adaptation strategy on sectoral coordination means that most federal agencies maintain mostly cross-sectoral ties and fewer cross-level ties. The resulting lack of cross-level connections may impede the multi-level governance of climate change adaptation due to insufficient communication and coordination between administrative levels. The one exception to this was the FOEN, which built many cross-level ties through its coordination of the pilot programme adaptation, underlining the importance of such programmes to fostering connections between levels and to providing higher-level support in the absence of clear legal mandates.

In conclusion, one of the most apparent ways to overcome some of the current primary barriers to climate change adaptation in Switzerland may be to foster local climate change adaptation through the provision of dedicated federal funding. Efforts should be made to build on the success of the pilot programme adaptation by identifying the most scalable climate change adaptation measures developed in the context of the programme and providing municipalities with concrete recommendations for approaching climate change adaptation, along with financial support for implementing those recommendations. As perceived risk exposure was identified as the most important condition necessary for local climate change adaptation to take place, awareness raising measures and informational campaigns on climate change adaptation should focus heavily on the risks climate change impacts pose to us already and how those risks will likely escalate in the near future. Lastly, a clear legal mandate for local climate change adaptation encoded into laws or regulations is needed to provide the political legitimisation and pressure to achieve comprehensive progress.

### 13.2 Contributions of the thesis to research and practice

This dissertation provides important theoretical, conceptual, methodical and empirical contributions to the literature, as well as valuable insights and good practice examples of great relevance to climate change adaptation. The analytical framework of this thesis primarily draws on two well-established concepts: multi-level governance and mainstreaming climate change adaptation. In this dissertation, I discuss the empirical importance of mainstreaming as a method of implementing recent climate change adaptation policies and measures and explain how climate change adaptation mainstreaming relates to similar concepts, such as environmental policy integration and climate policy integration. I then illustrate how research into barriers to adaptation can evolve beyond a functionalist understanding of policy design and implementation processes by combining it with a qualitative

analytical framework. Moreover, I apply Wamsler and Pauleit's (2016) mainstreaming strategy framework to the study of how climate change adaptation policies are being implemented in Switzerland and what barriers and success factors are most important during this process. This focus on mainstreaming strategies allowed me to illustrate causal mechanisms that explain why similar factors can become barriers to climate change adaptation in some cases and important success factors in others. In addition, I conceptualise the utilisation of specific mainstreaming strategies and the absence of others according to whether these approaches were beneficial or detrimental to the implementation of climate change adaptation policies and measures. In so doing, I paint a comprehensive picture of the various adaptation implementation approaches chosen at multiple administrative levels and in different policy sectors across Switzerland, as well as their respective strengths and weaknesses. Overall, I contribute empirically to the study of adaptation mainstreaming and barriers to adaptation by applying the mainstreaming strategy framework to the new case of Switzerland and conceptually by adding a new strategy to the framework based on a common Swiss approach to fostering horizontal mainstreaming.

On the practical side, the in-depth case studies presented in this thesis provide many good practice examples of multiple strategies that can be employed to implement climate change adaptation policies and measures when no clear legal mandates exist, or no additional funds have been dedicated. These findings are highly relevant even beyond the context of Switzerland, as climate change adaptation implementation efforts in many other wealthy, industrialised countries suffer from similar issues (Runhaar et al., 2018; Dupuis & Knoepfel, 2013). Cooperatively discussing priority climate change impacts, defining fields of action and assigning responsibility can serve as great entry points for the horizontal mainstreaming of climate change adaptation goals to foster cross-sectoral coordination. When it comes to concrete climate change adaptation measures at the local level, many important goals can be achieved by piggybacking adaptation objectives onto measures that also or even primarily pursue other goals, such as improving biodiversity or beautifying cities. When conducting pilot projects, win-win measures with immediately visible results can additionally serve as great awareness raising instruments to improve popular support for further climate change adaptation efforts. Following the good practice examples provided by the many projects sponsored by the pilot programme adaptation may support motivated parties in achieving incremental positive changes without dedicating significant resources to climate change adaptation. However, this thesis also clearly shows that moving beyond incremental and sporadic progress will require the provision of either clear legal mandates or dedicated climate change adaptation funds by superordinate administrative levels. As such, special interest groups and political movements looking to achieve comprehensive climate change adaptation progress should aim to achieve such changes rather than focusing exclusively on fostering adaptation at the local level.

On the theoretical level, the second paper focuses on the interactive roles of uncertainty and fragmentation between actors in policy design and implementation processes. The challenges posed by these issues are especially relevant to multi-level and multi-faceted issues, such as climate change adaptation, and they are aggravated even further by the relative recency of climate change adaptation as a policy field. The second paper outlines the importance of bridging actors that take on key roles in climate change adaptation governance networks. Conceptually and methodically, the paper contributes to the social network analysis literature by discussing why different conceptualisations of bridging actors matter, as well as how they can be applied and operationalised for the study of two-mode networks. Empirically, the study presents a social network analysis of key cross-sectoral and cross-level bridging actors based on a comprehensive assessment of the actors involved in the design and implementation of the Swiss national adaptation strategy. The results showed that, even in a multi-level governance setting where most concrete measures are designed and implemented at the local level, the federal level still plays an important coordinating role by disseminating information, providing venues for exchange between scholars and practitioners and building connections to peripheral actors. Additionally, the analysis clearly demonstrated how the strong focus of Swiss climate change adaptation governance on fostering horizontal coordination resulted in a lack of cross-level ties among almost all the most important bridging actors. The sole exception to this was the FOEN, which has established significant ties to cantonal, regional, local, and non-governmental actors by coordinating the pilot programme adaptation. Thus, this thesis demonstrates the importance of such pilot programmes, not only for fostering local adaptation, providing good practice examples and raising awareness, but also for building ties between relevant stakeholders. Lastly, the social network analysis revealed that two research institutes also held important bridging positions. I attribute this peculiarity to the complexity and variance of climate change impacts, the recency of climate change adaptation as a policy field and the uncertainty about optimal adaptation approaches caused by the absence of clear mandates or adaptation guidelines. As such, with respect to climate change adaptation implementation, relevant research institutes are uniquely positioned to spread their findings across a wide range of actors and may even foster ties between different stakeholders in doing so. Thus, efforts to communicate research results to the wider public and relevant practitioners should be especially emphasised in climate change adaptation research.

The final paper takes an in-depth look at conditions for local climate change adaptation, following the popular claim that adaptation research would be better served by analysing exactly why climate change adaptation does or does not happen rather than by compiling lists of barriers to adaptation. The first two articles of this thesis demonstrate that the lack of clear legal mandates or dedicated adaptation funds leaves local climate change adaptation highly dependent on the personal motivation of the local executives and stakeholders. Thus, deciphering the reasons underlying these motivations

becomes all the more important. Empirically, this third article makes an important contribution to the growing literature on local climate change adaptation progress in developed countries. Employing QCA, I identified necessary and sufficient conditions and combinations of conditions for local climate change adaptation to take place. The findings suggest that, while exposure to climate change impacts certainly plays an important role, the most important condition may be perceived risk exposure. This finding makes an important contribution to the literature on local climate change adaptation and is highly relevant for the practice of climate change adaptation. One important cornerstone of raising awareness and public support for climate change adaptation measures must clearly be the communication of how individuals are affected and endangered by climate change impacts and climate risks that are already relevant today rather than the risks that lie years in the future.

Altogether, the thesis constitutes an important addition to the growing literature on the practice of climate change adaptation in developed countries, the reasons for the prevalent adaptation implementation gaps in developed countries and possible pathways towards filling those gaps. The thesis depicts how climate change adaptation policies have been designed and implemented across administrative levels in Switzerland in the absence of clear legal mandates. It presents discussion on the implementation approaches that have been successful and why, as well as outlining the most important barriers to adaptation in Switzerland, how they have led to the Swiss adaptation implementation gap and how they can be overcome. Also addressed in this thesis are the actors who have taken on key roles in Swiss climate change adaptation governance, the importance of local climate change adaptation initiatives and their underlying motivations. While the empirical basis for these findings was exclusively Swiss, most of them are, nevertheless, applicable to many other wealthy developed countries suffering from similar adaptation implementation gaps.

### 13.3 Limitations of the thesis and pathways for future research

While my findings make important contributions to the practice and study of climate change adaptation governance, serious theoretical, methodical, and empirical limitations and open questions persist. These questions reveal potential pathways for future research.

As discussed in the introduction, one important issue that remains prevalent throughout climate change adaptation policy research is the dependant variable problem. The success of climate change adaptation policies and measures is difficult to evaluate because climate change adaptation is difficult to define and even more difficult to operationalise based on feasible measurable indicators – an issue exacerbated by the wide variety of climate change impacts and the resulting variety of climate change adaptation measures and the goals those measures aim to achieve. In consequence, climate change

adaptation policy outcomes are extremely difficult to measure and compare across cases. For my first paper, I dealt with this issue by selecting cases based on outputs, such as successfully published climate change adaptation strategies or successfully executed pilot projects. The evaluation of outcomes was based on the judgment of the interviewees. As such, it was generally qualitative in nature, largely subjective and difficult to compare across cases. A similar problem persists in my third paper. My assessment of whether a municipality was engaged in climate change adaptation measures was based on whether the municipality was conducting or at least participating in and benefitting from local measures that would reduce local climate risks or reduce vulnerability to the impacts of climate change if achieved. The dependant variable for the QCA was coded based on this question. Whether any such measures were successfully and completely implemented and what their exact outcomes were did not factor into the analysis. As such, while my findings grant important insights into the conditions underlying the climate change adaptation engagement of municipalities, they do not allow any definitive conclusions on whether that engagement resulted in tangible outcomes.

Developing a universally applicable method of operationalising climate change adaptation outcomes would fill an extremely important research gap and provide enormous benefits for the evaluation of climate change adaptation policies and measures both for practical and research purposes. Failing that, at the very least more research into how well climate change adaptation policy outputs translate into tangible outcomes is needed. Most current climate change adaptation evaluation processes handle the dependant variable problem of climate change adaptation research by focusing on policy outputs instead of outcomes.

One of the goals of this thesis was to identify actors who play key roles in Swiss climate change adaptation governance and find out how and why they came to take on these roles. These questions were primarily addressed in the second paper, which describes a social network analysis conducted to identify bridging actors in Swiss climate change adaptation governance networks. My rationale for researching bridging actors was based on the assumption that bridging actors would improve the outcomes achieved by actors within a network based on their ability to access a wide range of information, disseminate information throughout the network and foster coordination by connecting different actors within the network. However, this assumption was not empirically tested within the scope of this thesis, nor has it been well researched in the existing literature. Hence, more research into how bridging actors affect policy outcomes is needed. However, any such research analysing the case of climate change adaptation would also need to deal with the dependant variable problem.

My research into how climate change adaptation policies and measures were being implemented in Switzerland was theoretically focused on mainstreaming climate change adaptation across administrative levels and policy sectors. This focus was primarily motivated by the relevance of

mainstreaming in the current European and Swiss practice of climate change adaptation governance. Mainstreaming has been explicitly recommended by the EU as an approach for implementing climate change adaptation (COM, 2009). Furthermore, it is the most common approach chosen among OECD member states (Bauer & Steurer, 2015) and the explicit focus of the Swiss national adaptation strategy. Nevertheless, this focus on mainstreaming carries the risk of missing or underestimating the impacts of climate change adaptation measures conceived to alleviate specific climate risks without being embedded in an overarching strategy. As discussed in my third paper, such measures are not uncommon in smaller municipalities. Thus, my assessment of Swiss climate change adaptation governance may underestimate the role played by bottom-up single-issue focused climate change adaptation.

This theoretical limitation is reflected in an empirical limitation of the climate change adaptation governance mapping that served as the empirical basis for the social network analysis. The mapping constitutes a comprehensive assessment of Swiss climate change adaptation policies, measures and actors at the national level. It also includes all relevant policies, measures and actors at sub-national levels with clear connections to the national level. Additionally, the mapping incorporates a few case studies from sub-national levels that are not directly connected to the Swiss national adaptation strategy, such as the Grisons Cantonal Climate Strategy and the adaptation strategy of the city of Zurich. However, it does not include a comprehensive record of all cantonal, regional and local climate change adaptation initiatives that have taken place in Switzerland over the course of the last two decades. This empirical limitation may be one reason most of the bridging actors identified by the social network analysis of Swiss climate change adaptation governance were federal agencies. Additionally, climate change adaptation is a young and rapidly developing field of policy. Both the national action plan and the pilot programme adaptation have entered their second phase since the data collection process for the mapping was completed. As such, a promising starting point for further research would be to update my climate change adaptation governance mapping with more recent information and a more comprehensive assessment of cantonal climate change adaptation policies and measures. Doing so would lead to answering several interesting questions left unanswered by this thesis: Do federal agencies continue to take on such central roles in Swiss climate change adaptation governance or was that a temporary arrangement produced by the recency of climate change adaptation policy? Or possibly a misleading conclusion produced by the empirical shortcomings of my study? Are key bridging roles gradually taken over by cantonal actors as the cantons become more actively involved in climate change adaptation? Have the second phases of the national action plan and the pilot programme adaptation enabled federal agencies other than the FOEN to begin building more ties to climate change adaptation stakeholders at sub-national levels?

My research into the conditions underlying local climate change adaptation revealed that perceived exposure to climate change risks is an important necessary and sufficient condition for local climate change adaptation to take place. This is an important result in line with similar recent research that demonstrated the importance of public problem perception for policy processes (Ahmed et al., 2021; Glaus, 2021; Metz & Ingold, 2017). This opens many new questions on the exact influence of risk perception that may inspire future research: Does it matter which exact actors perceive these risks as more or less dire? How are these different perceptions formed, and how do measured exposure and recent extreme events flow into it? Is risk perception alone the decisive factor, or does the perception of potential measures matter as well? Are there risk perception thresholds that must be reached before action is taken?

However, it must also be acknowledged that my operationalisation of perceived climate risk in the context of the third thesis paper suffered from a few issues that may compromise the validity of my results. Perceived climate risk exposure was operationalised based on three indicators: a survey that inquired the degree to which respondents felt personally threatened by the impacts of climate change, an expert assessment of how concerned the populace of a specific municipality was about local natural hazards and an expert assessment of how concerned the populace of the same municipality was about the impacts of climate change. Unfortunately, the survey data were aggregated at the cantonal level, so its validity at the municipal level is questionable. The expert assessments, on the other hand, may reflect the personal risk perception of the interviewees rather than the prevalent opinion among the populace of their municipalities, or they may be distorted to overrepresent the opinion of more outspoken, politically active members of the municipalities within my sample. Thus, their validity, too, is not above reproach. Therefore, testing the validity and reliability of my results by repeating a similar study based on survey data aggregated at the local level would be a worthwhile endeavour.

The third paper also uncovered that well-resourced local natural hazard management was a highly necessary condition for local climate change adaptation. However, I concluded that this was overall a trivial result, as the municipalities within my sample almost universally had very well-resourced local natural hazard management. Nevertheless, it would be interesting for follow-up studies to check the importance of this condition beyond the Swiss context with a sample that included some cases in which natural hazard management either struggles with a lack of resources or is non-existent.

Finally, the most serious empirical limitation of my dissertation is that it focuses exclusively on the case of Switzerland. Nevertheless, this allowed me to develop a thorough understanding of climate change adaptation governance in Switzerland through a combination of quantitative and qualitative methods, including a comprehensive mapping of climate change adaptation governance at the national level combined with a number of in-depth case studies on cantonal, regional and local climate change

adaptation. However, how reliably my results can be applied internationally remains an open question. Certainly, some of the climate change adaptation mainstreaming strategies I discuss can be applied beyond the context of Switzerland. My findings on important barriers and success factors for climate change adaptation, how they develop and how they can be addressed are also relevant beyond the case of Switzerland. Moreover, most of my findings are likely primarily relevant for climate change adaptation in other wealthy, developed countries with strong traditions of multi-level governance. To what degree my findings can be empirically reproduced in other countries is an important topic for future research.

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# 14 Climate adaptation in practice: how mainstreaming strategies matter for policy integration

**Running Title**

Climate adaptation through mainstreaming

**Keywords**

environmental governance; climate change adaptation; environmental policy integration; climate policy integration; governance of implementation; mainstreaming

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**Conflict of Interest**

The authors declare that they have no conflict of interest.

## 14.1 Abstract

With some level of climate change now inevitable, climate policy around the world has evolved in recent decades to include adaptation to the impacts of climate change. Most industrialized countries have formulated national adaptation strategies to meet this challenge. However, the implementation of on-the-ground measures is lagging. To analyze the implementation process and possible reasons for the implementation gap, we take a closer look at how the integration of adaptation goals into various sectoral policies—often called mainstreaming—has been handled on different administrative levels in Switzerland. Going beyond traditional compilations of barriers to climate change adaptation, we analyze the use of six different mainstreaming strategies across cases and levels and the reasons for their success or lack thereof. We find that different actors at all administrative levels have successfully employed programmatic mainstreaming in combination with inter-organizational mainstreaming to foster horizontal cooperation. We call this strategy cooperative mainstreaming. Some pioneers even managed to channel their successes into advances in regulatory mainstreaming. However, the lack of systematic regulatory and directed mainstreaming on the national and cantonal levels largely limits adaptation actions on lower levels to those cases where the major impetus derives from extreme events or proactive individuals on the ground. We conclude that the adaptation implementation gap in Switzerland largely stems from the lack of political commitment to promoting local adaptation at the national and cantonal levels.

## 14.2 Keywords

Climate policy; climate change adaptation; environmental policy integration; climate policy integration; implementation gap; mainstreaming

## 14.3 Introduction

Owing to significant, now unavoidable, impacts of climate change, the adaptation to climate change has grown to be an increasingly important policy field in recent decades (Bauer et al., 2012). One of the biggest challenges for adaptation policymaking is the fact that climate change impacts come in a broad variety and cut across the domains of multiple traditional policy sectors. Among member states of the Organisation for Economic Cooperation and Development, multi-sectoral national adaptation strategies have emerged as the most common approach to handle this challenge (Bauer & Steurer, 2014). These strategies commonly aim to integrate climate change adaptation goals into the various sectoral policies that guide the work of the relevant state departments and agencies. This process is often referred to as mainstreaming climate change adaptation.

However, recent research has shown that while adaptation policies are advancing in many countries, the implementation of on-the-ground measures is not progressing equally well. As Dupuis and Knoepfel (2013) put it, “adaptation policies have often consisted of enunciating general objectives, formulating guidelines, and funding climate impact research programs; however, concrete actions seem to lag behind” (p. 30). The reasons for this implementation gap are yet unclear. Early adaptation studies have often adopted a functional understanding of the policy process (Dupuis & Knoepfel, 2013; Smit & Pilifosova, 2003). They reason that a country’s ability to design and implement adaptation policies would essentially depend on the capabilities of its populace and the resources available to them. Thus, they measure a country’s capacity for adaptation based on macro indicators such as Gross domestic product per capita or literacy rates that are strongly correlated with economic development (Dupuis & Knoepfel, 2013). However, this perspective largely fails to explain the implementation gaps in industrialized countries (Wolf, 2011).

As case studies have shown, many of the policies and actions that have been successfully implemented are extensions of existing policies (Eisenack et al., 2014). As such, mainstreaming has proven to be an important enabling factor for adaptation to climate change. However, hardly any scientific consensus exists on what exactly successful mainstreaming is supposed to achieve or how its effectiveness could be measured (Runhaar et al., 2018). Indeed, many authors do not even agree on their exact definitions of mainstreaming.

Our goal is to investigate the adaptation implementation gap, the reasons for its persistence, and the possible role of mainstreaming in overcoming it. To this end, we conducted case studies of adaptation implementation measures at the local level in Switzerland. Building on a framework of different mainstreaming strategies developed by Wamsler and Pauleit (2016), we investigate the following three research questions:

1) What adaptation mainstreaming strategies were employed?
2) In what respect were the employed mainstreaming strategies a success factor for the implementation of adaptation measures and policies?
3) In what respect was the lack of mainstreaming a barrier for adaptation?

### 14.4 Theory

According to the European Union (EU), for adaptation policy to be successful, its goals must be integrated—or mainstreamed—into existing policy sectors. The EU White Paper on adapting to climate change demands a "review of how policies could be re-focused or amended to facilitate adaptation" for each policy sector (COM, 2009, p. 8). Empirical studies find that the mainstreaming of adaptation policies is one of the key means by which adaptation is supposed to be promoted throughout EU member states (Bauer et al., 2012; Biesbroek et al., 2010; Widmer, 2018). A literature review on the expected benefits of mainstreaming substantiates this focus: mainstreaming is key to take optimal advantage of synergy effects and to eliminate incoherencies and goal conflicts (Kok & de Coninck, 2007; Uittenbroek et al., 2013) by improving policy coordination across sectors and levels (Adelle & Russel, 2013). Some authors have pointed out the possible disadvantages of relying too heavily on mainstreaming: compared with a dedicated approach that includes new institutions devoted to adaptation with their own budget and a clear political mandate, relying on mainstreaming for implementing adaptation goals runs the risk of adaptation playing second fiddle to other policy goals and being regarded as nice to have rather than non-negotiable. It may also reduce the political visibility of the topic and lead to loss of attention over time (Runhaar et al., 2018). Nevertheless, adaptation mainstreaming clearly promises many advantages.

However, as Brouwer et al. (2013) note, neither policy practice nor the scientific literature has a universally agreed upon definition of what mainstreaming exactly is. Massey and Huitema (2016) define adaptation mainstreaming as an instrument to implement adaptation policies and activities regardless of specifics. Similarly, many governments define adaptation mainstreaming as the integration of climate change adaptation policy goals into existing policies. Hence, many researchers conceptualize adaptation mainstreaming as a specific instance of environmental policy integration (EPI) (Adelle & Russel, 2013; Massey & Huitema, 2016; Runhaar et al., 2014). This interpretation is consistent with the fifth assessment report of the Intergovernmental Panel on Climate Change, which uses the term mainstreaming synonymic to integrating climate change adaptation considerations into "policy making, planning, and decision making" across levels and sectors (IPCC, 2014, p. 886). Thus, we build on the existing literature on EPI and mainstreaming to explore how mainstreaming can be conceptualized.

Arild Underdal (1980) introduced the concept of policy integration and defined integrated policy as policies that meet three criteria: comprehensiveness, aggregation, and consistency. The concept was subsequently adopted by different authors in reference to the integration of environmental issues into existing policy areas (Jordan & Lenschow, 2010; Lafferty & Hovden, 2003; Runhaar et al., 2009, 2014), leading to the development of the EPI concept and, more recently, of EPI offshoots such as climate policy integration (CPI) (Adelle & Russel, 2013; Jordan & Lenschow, 2010; Mickwitz & Kivimaa, 2007) or climate policy mainstreaming. As Candel and Biesbroek (2016, pp. 212–213) argue, throughout this development, the basic premise stayed unchanged: "The objective of EPI is to incorporate, and, arguably, to prioritize, environmental concerns in non-environmental policy domains, with the purpose of enhancing environmental policy outcomes." They allude to one of the key conceptual questions concerning EPI: Should the concept include a normative judgement regarding the importance of environmental issues, or does EPI merely consist of ensuring that environmental concerns are considered during policy decisions across sectors? The first view, which defines successful EPI as a prioritization of environmental issues across sectors, is often referred to as the normative view, whereas the weaker conceptualization of EPI is known as the rational view (Persson, 2004).

Among the main proponents of the normative view are William Lafferty and Eivind Hovden, who argue that EPI must go beyond merely employing "good policy-making strategy" (Lafferty & Hovden, 2003, p. 7) by taking advantage of synergies or eliminating contradictions. They demand that environmental objectives must be given "principled priority" (p. 9) over traditional sectoral policies and objectives. Whereas many authors follow this definition, others such as Camilla Adelle and Duncan Russel fall back to the original definition by Underdal, pointing out that "implementation experiences in the EU […] show us that far weaker interpretations of EPI can be seen in its day-to-day operation than those espoused in the academic literature" (Adelle & Russel, 2013, p. 4). They also remark that although conceptually similar to EPI, the literature on CPI and climate adaptation mainstreaming appears more in line with Underdal's original conception of EPI. They attribute this difference to the developmental background of many papers on CPI and adaptation mainstreaming, reasoning that the focus on development does not lend itself to assigning principled priority to environmental issues.

More recently, scholars have begun incorporating both interpretations of what constitutes EPI into their analytical frameworks. Persson et al. (2018, p. 113) define EPI as "the incorporation of environmental objectives in non-environmental policy sectors" to avoid "inconsistences and incoherence between the policies of different sectors" as well as to eliminate the "gaps in sectors' environmental responsibility." Whereas this definition follows along the line of rational conceptualizations, the analytical framework employed by all the empirical contributions to the special issue distinguishes between three levels of intensities of integration: coordination, harmonization, and

prioritization (Persson et al., 2018). Here, coordination is defined as avoiding contradictions between sectoral policies, harmonization is defined as treating environmental objectives as equally important to sectoral objectives, and prioritization is defined as prioritizing environmental objectives over sectoral objectives. Applying this framework, Widmer (2018) analyzes the development of the Swiss national adaptation strategy (NAS) and its influence on different sectoral strategies. He finds that the NAS has led to adaptation mainstreaming into key sectors but to varying degrees. Adaptation mainstreaming was particularly successful in the natural hazard management and forestry sectors, whose traditional objectives are arguably the most in line with adaptation objectives. He also notes that "even though adaptation has been included in the sectoral strategies and action plans for natural hazards, forestry, biodiversity, and agriculture, coordination remains absent" and that the implementation of new instruments is severely lacking (Widmer, 2018, p. 77).

Much of the literature analyzing CPI and mainstreaming has focused on compiling lists of barriers to mainstreaming, the implicit reasoning being that the implementation gap may be resolved if only these barriers could be overcome. Recent studies (Biesbroek et al., 2015; Wellstead et al., 2018) criticize this focus on barriers as a functionalist approach that does not contribute to our understanding of causal mechanisms. Instead, they call for empirical research that focuses on explaining observed outcomes by identifying plausible causal mechanisms applicable to the context of the case (Biesbroek & Candel, 2019; Wellstead et al., 2018). For example, in their work "Mechanisms for policy (dis)integration: Explaining food policy and climate change adaptation policy in the Netherlands," Biesbroek and Candel (2019) apply an approach that demonstrates the non-linear nature of policy integration processes and the variety of causal mechanisms that may influence them.

## 14.5 Analytical Framework

### 14.5.1 Conceptualizing mainstreaming

Although Widmer (2018) provides insights into how the mainstreaming of climate adaptation into sectoral policies has progressed in Switzerland, he does not go into detail regarding how it was done or what strategies were employed. In addition, his focus on the NAS and relevant sectoral policy documents limits his results to the national level, as the Swiss NAS was explicitly designed to address members of the national administration. To overcome the implementation gap, adaptation goals must be mainstreamed into concrete measures at the local and regional levels. Because climate change impacts, institutional and political contexts, and resources drastically vary across different geographical areas, there can be no one-size-fits-all solutions. As such, to understand how adaptation mainstreaming can contribute to overcoming the implementation gap, it is important to look at how adaptation goals are mainstreamed into non-environmental sectors not only at the national level but also at the regional and local levels.

Hence, we are interested in conceptualizations of mainstreaming that include both the vertical and horizontal integration of adaptation goals. Wamsler and Pauleit (2016) developed a framework of six mainstreaming strategies based on a literature review of activities performed to mainstream cross-cutting issues. They define climate mainstreaming as "the inclusion of climate considerations in sector policy and practice" with the goal of changing policy paradigms at different administrative levels. The strategies in their framework include both procedural factors and policy outputs. The strategies are also "comprehensive and complementary in the sense that [they] are all required for achieving sustainable transformation" (Wamsler & Pauleit, 2016, p. 73).

| | |
|---|---|
| 1) | **Add-on mainstreaming:** The establishment of specific on-the-ground projects or programmes that are not an integral part of the implementing body's sector work but directly target adaptation or related aspects. |
| 2) | **Programmatic mainstreaming:** The modification of the implementing body's sector work by integrating aspects related to adaptation into on-the-ground operations, projects or programmes. |
| 3) | **Managerial mainstreaming:** The modification of managerial and working structures, including internal formal and informal norms and job descriptions, the configuration of sections or departments, as well as personnel and financial assets, to better address and institutionalize aspects related to adaptation. |
| 4) | **Intra- and inter-organizational mainstreaming:** The promotion of collaboration and networking with other departments, individual sections or stakeholders (i.e., other governmental and non-governmental organizations, educational and research bodies and the general public) to generate shared understanding and knowledge, develop competence and steer collective issues of adaptation. |
| 5) | **Regulatory mainstreaming:** The modification of formal and informal planning procedures, including planning strategies and frameworks, regulations, policies and legislation, and related instruments that lead to the integration of adaptation. |
| 6) | **Directed mainstreaming:** Higher level support to redirect the focus to aspects related to mainstreaming adaptation by e.g., providing topic-specific funding, promoting new projects, supporting staff education, or directing responsibilities. |

**Table 14-1: Mainstreaming strategy framework. Source: Wamsler and Pauleit (2016)**

One of the main advantages of this framework is that it is applicable to the mainstreaming of different issues and at all administrative levels. Although strategies 1–3 (see table 1) are important at all administrative levels, they do not concern the interactions between levels. However, strategies 4–6 include some measure of vertical integration: inter-organizational mainstreaming covers the interactions between governmental actors on different administrative levels as well as the interactions between governmental and non-governmental actors. Regulatory mainstreaming may concern both vertical and horizontal integration depending on the level of the planning procedures in question as well as the level(s) addressed therein. Finally, directed mainstreaming stands out from the other strategies in that it is specifically about vertical integration: the phrase "higher level support" presupposes interactions between different levels.

With the inclusion of add-on mainstreaming, the framework incorporates dedicated approaches to foster adaptation goals. It thus departs from those definitions of adaptation mainstreaming that explicitly differentiate between dedicated approaches and sectoral integration (Dewulf et al., 2015; Uittenbroek et al., 2014).

### 14.5.2 Identifying causal mechanisms

Biesbroek et al. (2015) propose turning to conclusions from implementation research to identify the causal mechanisms that determine "how implementation processes work, and succeed or fail" (pp. 493–494). An established paradigm in policy implementation research is the fact that successful implementation becomes more or less likely based on policy design (Hupe, 2010; Pressman & Wildavsky, 1984). Chun and Rainey (2005a, 2005b) demonstrate the importance of goal clarity: to be successfully implemented, policy goals must be well defined, precisely formulated, and as easy to operationalize as possible. However, as Hupe (2010) points out, the "managerial competence and professionalism" or the "governance skills" of the public actors involved in the implementation of a policy may make up for a lack of goal clarity: "given the need to act, [implementers] usually will try to make the best of it, even in situations of goal ambiguity" (pp. 75–77). In other words, if political goals are not formulated or defined clearly enough by higher administrative levels, successful implementation depends not only on the governance skills of the local implementers but also on their motivation to act.

Hupe's conclusions provide some insights into how and why the chances for successful implementation may be affected by the different mainstreaming strategies. Goal clarity depends on directed and regulatory mainstreaming. Regulatory mainstreaming covers any modifications of strategies, policies, legislation, and regulation pertaining to the integration of adaptation goals. Thus, goal clarity regarding climate change adaptation policies is directly dependent on whether and how adaptation goals have been integrated into planning procedures. As such, we expect regulatory mainstreaming to increase goal clarity and therefore the odds of successful implementation. Should regulatory mainstreaming be lacking, we would expect to see more goal ambiguity and consequently a higher dependence on the governance skills and motivations of local implementers for implementation.

Directed mainstreaming encompasses activities such as providing topic-specific funding, promoting new projects, supporting staff education, or directing responsibilities (see table 1). Such activities implicitly contribute to the clarification of overall policy goals: the provision of funding dedicated to specific purposes usually comes with expectations and conditions regarding the results of the financed activities. Similar arguments apply in the case of promoting new adaptation projects. Staff education may include the transfer of knowledge on the exact goals of adaptation policies and measures. Directing responsibilities will usually include some amount of defining and clarifying the new

responsibilities, which increases goal clarity. Thus, we expect directed mainstreaming to increase goal clarity. Programmatic mainstreaming also serves to increase goal clarity, as it translates higher-level policy goals into concrete, lower-level objectives to be met by local civil servants in their day-to-day activities.

Another important factor that co-determines the chances for successful policy implementation is what Hudson et al. (2019) call “implementation in dispersed governance” (p. 3). Policy implementation depends on local contexts and the behavior of local level staff who have considerable autonomy in their implementation of higher-level policies. This may hinder the implementation of national policies. Hudson et al. (2019) call for better policy prioritization, tracking, and monitoring to better support the implementation of policies whose implementation suffers owing to dispersed governance. However, the relevance of local civil servants also has a flip side: according to Hupe (2010), “governance skills” such as the managerial competence of the civil servants who implement concrete measures at the local level can compensate for factors that would otherwise hamper implementation, such as low goal clarity. We expect managerial mainstreaming to increase these governance skills. Similarly, intra- and inter-organizational mainstreaming measures meant to increase the adaptation-related knowledge and competence of the participants also increase their governance skills.

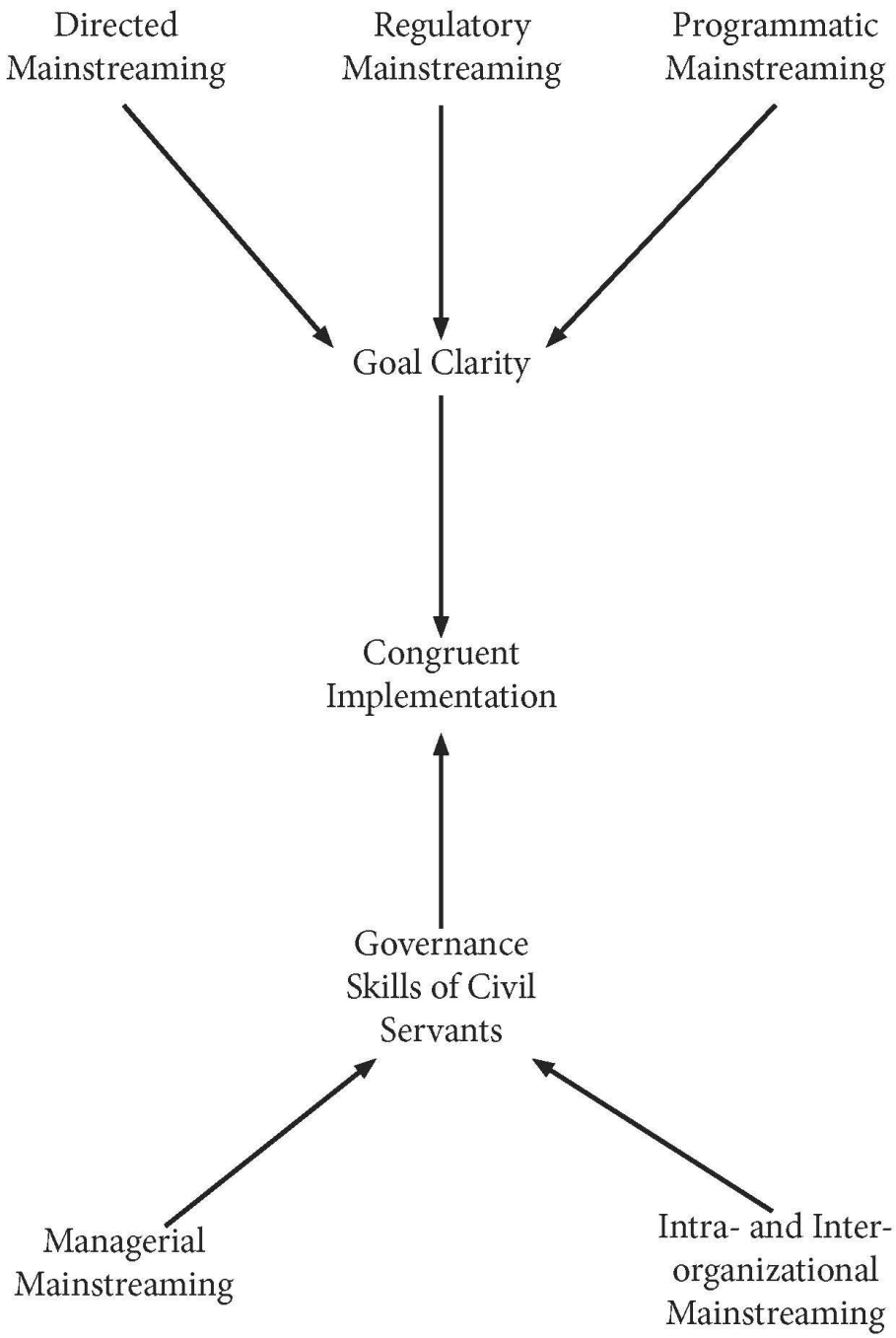


**Figure 14-14-1: Causal mechanisms between mainstreaming strategies and implementation**

Although we agree with Biesbroek et al. (2015) that adaptation research should strive to explain causal mechanism, we also agree with Eisenack et al. (2015) that focusing on barriers to adaptation need not

mean adopting a functionalist or top-down view. To understand the reasons for the implementation gap and the role adaptation mainstreaming may play in overcoming it, we still need to look at the influential factors—factors that either hinder or support the implementation of adaptation measures. As Eisenack et al. (2014) assert, the problem with much of the conventional literature on adaptation barriers is that researchers do not pay sufficient attention to explaining why certain factors become barriers in certain contexts. Influential factors are specific to unique cases and are valued differently by different actors. However, once one understands why certain factors are hindering in some cases yet helpful in others, one may begin to generate transferable knowledge on how to optimally deal with said factors.

The plausible causal mechanisms we identify based on our review of the policy implementation literature suggest explanations why adaptation mainstreaming may be a promising avenue for implementing adaptation policies (see figure 2). To check the validity of these explanations and answer our research questions, we have conducted six case studies on the implementation of local adaptation policies and measures in Switzerland. We investigate which, if any, mainstreaming strategies were employed in each case and discuss in what contexts and why these strategies did or did not find success.

## 14.6 Data and Method

### 14.6.1 Case selection

To assess the large variety of local adaptation implementation efforts, we chose cases from drastically different contexts. Our goal was to include cases embedded in national and cantonal policy programs as well as cases of largely independent local adaptation. The most prominent climate change adaptation policies at the national level in Switzerland are the two parts of the adaptation strategy of the federal council. The first part of the strategy defines the goals, challenges, and fields of action. The second part is an action plan, which defines 63 measures for implementing the adaptation strategy to be performed by federal departments and agencies. One of these measures is the Pilot Program Adaptation to Climate Change, which funded 31 regional and local adaptation projects. From among these pilot projects, we chose four cases. We interviewed representatives of the organizations in charge of the projects as well as the representatives of the federal agencies involved in the funding of the projects via the pilot program. We also conducted two interviews on the pilot program itself to better understand the structure these projects were embedded in.

In addition, we wanted to assess both projects that were supported by the cantonal level and projects that were not. The canton of Grisons stands out as an especially proactive canton regarding climate change adaptation. Grisons was one of the first cantons to formulate a cantonal climate strategy that

included climate change adaptation. As such, we chose the three pilot projects that took place in Grisons as our cases. Although they were all originally developed for and co-funded by the pilot program, they were also loosely embedded within the cantonal climate strategy Grisons and received some additional funds from cantonal agencies. Consequently, we also conducted several interviews with members of the cantonal administration of Grisons on the development and implementation of the cantonal climate strategy to better understand how local projects were embedded in the strategy.

As a counterpoint to Grisons, we included project Acclimatasion, which is often presented as one of the major success stories of the pilot program. Acclimatasion took place in the canton of Valais, which has so far done very little to foster climate change adaptation. It also represents a case of urban adaptation. Cities are both one of the major contributors to climate change and especially vulnerable to many climate change impacts (Reckien et al., 2014). As such, many researches expect them to play a key role in global efforts to mitigate climate change and adapt to its consequences (Reckien et al., 2014). Owing to the importance of the principle of subsidiarity in the Swiss political system, the municipal level is an important political authority. Thus, we chose to analyze adaptation to climate change in two additional Swiss cities unaffiliated with the pilot program: Zurich and Biel. In recent years, the city of Zurich has developed the foundation for effective inter-sectoral climate change adaptation (Parlow et al., 2010). Biel was suggested as an interesting case during preliminary expert workshops because despite efforts to the contrary, it has so far achieved little meaningful adaptation progress. These two cases serve to round out our case selection as two cases that did not receive direct significant support from either the national or the cantonal level. In total, we investigated six cases of local adaptation implementation efforts. Table 2 lists each of these six cases and summarizes the primary goals of each project.

| **Project Name** | **Project Goals** |
|---|---|
| Project Aquafutura | Prepare water management within the region Parc Ela for the impacts of climate change |
| Project Climate Toolbox Surselva | Create a toolbox to sensitize municipal executives to the impacts of climate change and assist them in developing adaptation measures |
| Project Davos +1.7°C concrete: From climate change to climate action | Sensitize the population of Davos to the local impacts of climate change and possible adaptation measures |
| Project Acclimatasion: Climate-adapted urban development for Sion | Implement small-scale adaptation measures in the city of Sion |
| Climate adaptation in the city of Zurich | Formulate a municipal adaptation plan to organize inter-sectoral cooperation, identify climate impacts, and develop a basis for future measures |

| | |
|---|---|
| Climate adaptation in the city of Biel | Identify climate impacts, prepare possible adaptation measures, and establish a basis for inter-sectoral cooperation |

Table 14-2: Cases and primary project goal

The selected cases are grouped in three partially overlapping clusters: pilot projects funded by the national pilot program adaptation, cases embedded in the implementation of the cantonal climate strategy Grisons, and cases of urban adaptation (See figure 2). Importantly, two of the three clusters include more data than just the sum of the local cases contained within each of them, as we also conducted empirical research on the pilot program adaptation and the cantonal climate strategy Grisons.

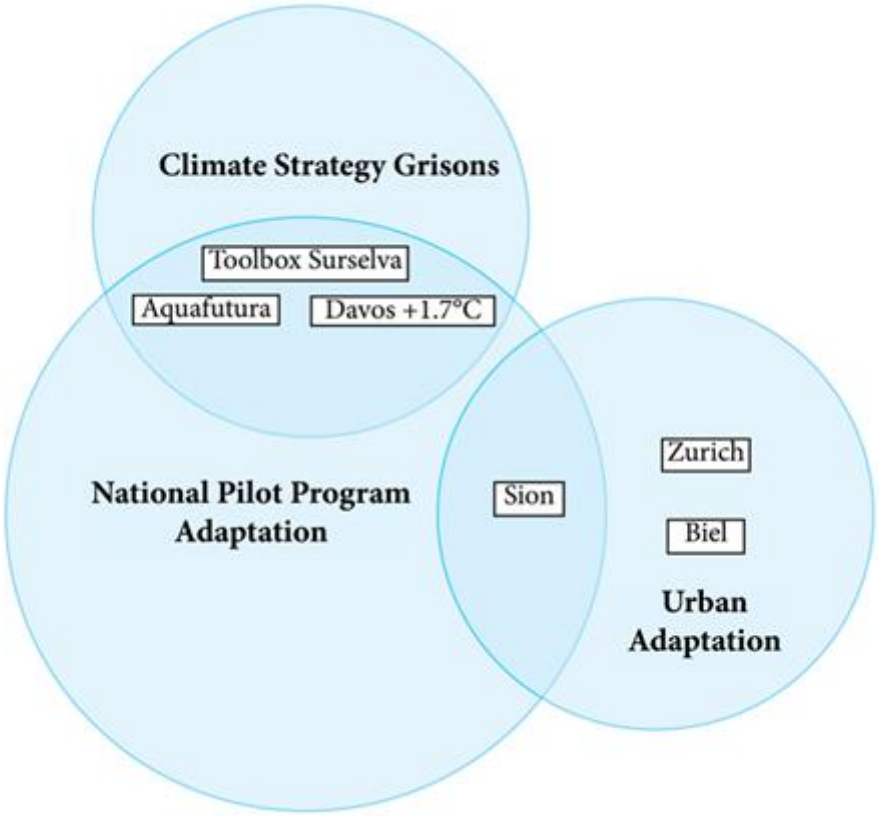


Figure 14-14-2: Membership of cases within case clusters

### 14.6.2 Data

We started the data collection process by thoroughly analyzing any relevant official documents to develop a general understanding of our cases and their respective success or lack thereof. Our document analysis also served to identify relevant stakeholders and promising interviewees. Important documents included the adaptation strategy and action plan of the federal council, progress and final reports on pilot projects and the pilot program, and the cantonal climate strategy Grisons and corresponding progress reports on different sectoral measures.

For each case, we interviewed people representing different sectors and administrative levels as well as non-governmental entities involved in the implementation of the policy or measure in question, conducting a total of 24 interviews. Table 3 shows the number of interviews conducted per case arranged by stakeholder categories. The sum of interviews according to table 3 is higher than 24 because many of our interviews with governmental stakeholder at higher jurisdictional levels were relevant to several of our cases.

| Case | National Authorities | Cantonal Authorities | Local Authorities | NGOs | Private Agencies | Total |
|---|---|---|---|---|---|---|
| Aquafutura | 2 | 1 | 0 | 1 | 0 | 4 |
| Climate Toolbox Surselva | 1 | 2 | 1 | 0 | 0 | 4 |
| Davos + 1.7°C | 1 | 1 | 1 | 0 | 1 | 4 |
| City of Sion (Acclimatasion) | 2 | 0 | 1 | 1 | 0 | 4 |
| City of Zurich | 0 | 1 | 2 | 0 | 1 | 4 |
| City of Biel | 0 | 0 | 3 | 1 | 0 | 4 |
| National Pilot Program Adaptation | 4 | 0 | 0 | 0 | 0 | 4 |
| Climate Strategy Grisons | 0 | 5 | 0 | 0 | 1 | 6 |

Table 14-3: Number of Interviews per case by stakeholder category

The interviews were designed to reveal who worked together with whom in what way, to what effect, and during which part of the policy cycle. Most importantly, because we were interested in the adaptation implementation gap, we focused on identifying the factors that either hindered or helped the implementation of adaptation policies and measures as well as the underlying contexts and mechanisms that caused them to become influential factors. We also focused on how these barriers were overcome—or in the case of success factors, how they were optimally taken advantage of—or why the involved actors ultimately failed to do so.

Some interviewees were fairly critical of the actors they worked with, including governmental authorities at higher jurisdictional levels and in some cases even their own employers. Thus, the confidentiality of our data may be a concern, as some interviewees could possibly suffer professional consequences if their statements were identified. All interviewees consented to the publication of scientific studies and reports based on their statements so long as no specific statements are ascribable to one specific person. We have ensured this, as we interviewed multiple people for each case and do not directly allocate any specific statements to any specific interviewee. We also do not identify interviewees beyond stakeholder category and respective case.

### 14.6.3 Method of analysis

To evaluate the interview data, we conducted qualitative content analysis (Kuckartz, 2012; Mayring, 2000, 2014). We developed a coding system to classify the different sections of the interviews according to the topics discussed. After the first round of coding, we revisited all interview sections pertaining to barriers or success factors and determined if the discussion was related to the successful employment or a lack of mainstreaming. Finally, for the sections discussing mainstreaming or the lack thereof, we determined which specific mainstreaming strategy or strategies best fit the issues in question. This coding procedure allowed us to focus our attention on our research questions.

First, we present the most important barriers and success factors related to either the employment of a specific mainstreaming strategy or the lack thereof. Next, we elaborate on the role the different mainstreaming strategies played across cases. We then discuss the patterns that emerge on comparing the different cases and case clusters and the conclusions we can draw regarding the role different mainstreaming strategies play for the state of climate change adaptation in Switzerland.

## 14.7 Results

Table 4 shows the most important success factors and barriers for all our cases as well as which mainstreaming strategies are relevant to these factors and barriers either because the success factors denote a good example of their employment or because the barriers relate to a lack of mainstreaming.

Note that both the use and the lack of the same mainstreaming strategy may have been influential factors for the same case in reference to different contexts. For example, in the case of Sion, the directed mainstreaming activities at the federal level were an important success factor, whereas the lack of directed mainstreaming activities by the canton of Valais was a barrier.

| Case | Main Success Factors | Relevant Strategy | Main Barriers | Relevant Strategy |
|---|---|---|---|---|
| Aquafutura | Guidance, funding, and legitimization provided by the national level<br>Cooperation with municipalities in the project region | Dir<br>Int | Incoherent water management legislation<br>Lack of political interest at the regional level<br>No established cooperation between municipalities | Reg<br>Manag<br>Int |
| Climate Toolbox Surselva | Guidance, funding, and legitimization provided by the national level<br>Support by the cantonal agency for the environment<br>Networking activities | Dir<br>Int<br>Int | Lack of interest at the cantonal agency for the economy and tourism<br>Lack of interest at the local level<br>No legal mandate by the canton for climate adaptation | Dir & Manag<br>Int<br>Reg |
| Davos +1.7°C | Guidance, funding, and legitimization provided by the national level<br>Cooperation with national and cantonal levels | Dir<br>Int | Lack of financial resources at the local level<br>Very few funding programs for climate adaptation at the national and cantonal levels | Dir<br>Dir |
| Acclimatasion | Guidance, funding, and legitimization provided by the national level<br>Piggybacking of adaptation measures onto existing developmental projects<br>Realization of concrete, local results to show off and raise awareness<br>Mainstreaming of adaptation goals into municipal planning policies | Dir<br>Prog<br>Add-On<br>Reg | Lack of support at the cantonal level<br>No authority responsible for climate adaptation at the cantonal level | Dir<br>Manag |
| Zurich | Legitimization provided by the national level<br>Information provided by the national level<br>Information exchange with other cities<br>Cross-sectoral cooperation<br>Avoidance of traditional sectoral rivalries<br>Mainstreaming of adaptation goals into daily tasks | Dir<br>Dir<br>Int<br>Int<br>Manag & Int<br>Prog | No legal mandate<br>Lack of cantonal support<br>Existing laws and policies incoherent with adaptation goals | Reg<br>Dir<br>Reg |

| | | | | |
|---|---|---|---|---|
| Biel | Legitimization provided by the national level<br>Individual municipal officials mainstreaming adaptation goals into daily tasks | Dir<br>Manag & Prog | No legal mandate<br>Lack of national support<br>Lack of cantonal support<br>Uncertainties about responsibilities<br>Lack of cross-sectoral cooperation | Reg<br>Dir<br>Dir<br>Manag<br>Int |

Table 14-4: Main barriers and success factors by case and relevant mainstreaming strategy

Overall, we find ample evidence in support of the importance of mainstreaming. The employment of different mainstreaming strategies is frequently recognized as an important success factor, whereas many barriers are related to a lack of mainstreaming or could be overcome through mainstreaming. Across all cases, mainstreaming strategies were relevant to about half the discussed influential factors. Mainstreaming was also relevant to at least one of the discussed influential factors in every single case.

However, not all six mainstreaming strategies were equally important: only few influential factors related to managerial mainstreaming were mentioned, and add-on mainstreaming was only mentioned once.

### 14.7.1 Inter-organizational and programmatic mainstreaming

All interviewees addressed the importance of inter-sectoral cooperation and thus inter-organizational mainstreaming for climate change adaptation. A combination of inter-organizational and programmatic mainstreaming has been crucial in promoting horizontal cooperation across almost all cases. The interviewees representing the federal level, cantonal agencies of Grisons, and the cities of Sion and Zurich all advocated cooperatively developing plans for climate change adaptation between all concerned sectors. Responsibilities were distributed among those sectors and were to be integrated into their regular workload via programmatic mainstreaming. Across most of our cases, similar approaches have been successful in bridging the gaps between traditionally rival sectors such as the environmental sector and the agricultural sector or the economic sector.

Representatives of the cantonal agencies of Grisons commonly stressed the importance of regular exchange among agencies to foster inter-sectoral cooperation. Their annual cantonal climate conference increases the awareness of the attendees regarding issues related to climate change adaptation and improves their related skills. It also serves as a measure of social control: representatives from each cantonal agency involved in the implementation of the cantonal climate strategy report on their progress during the recent year. This keeps the topic fresh in everybody's mind and pressurizes agencies into producing some tangible results to avoid embarrassment among their peers.

The city of Biel stands out as the case where little progress toward inter-sectoral cooperation has been achieved so far. One important reason for this deficit was the failure of attempts to organize inter-sectoral cooperation regarding climate change a few years ago. This failure was attributed to the conflicting personalities and inappropriately steep hierarchy structures between the involved sectors. Nevertheless, Biel has achieved some success in promoting measures for climate change adaptation by piggybacking adaptation measures onto already ongoing structural development processes. This

kind of programmatic mainstreaming has found similar success in Sion and was cited by project managers as one of the main success factors for Acclimatasion.

### 14.7.2 Directed and regulatory mainstreaming

Our case studies also demonstrate the importance of directed and regulatory mainstreaming in several ways. First, the personal engagement and motivation of important stakeholders and the acute problem pressure generated by current extreme events were omnipresent influential factors. This is nothing new; studies have long held that individual motivations play an important role in how policies are locally implemented (McLaughlin, 1987). However, the universal importance of such factors across all our cases indicates that directed and regulatory mainstreaming may be lacking in Switzerland (Braunschweiger et al., 2018). The resulting low goal clarity makes implementation dependent on the initiative and governance skills of local stakeholders.

Second, interviewees representing pilot projects financed by the pilot program adaptation often stressed the importance of their good working relationship with the federal level. The pilot program and its anchoring in the federal action plan provided not only funding but also important guidance and legitimacy to the projects. Being embedded in a national program and legitimized by the federal adaptation strategy heavily contributed to the acceptance of the projects at the local level. In addition, the structural demands of the pilot program and the regular exchange with federal agencies served to improve goal clarity for the projects.

Third, a comparison of the three pilot projects taking place in the canton of Grisons and the project taking place in the canton of Valais showcases the difference between cantonal adaptation policies. Grisons was the first canton to adopt a cantonal climate strategy that included climate change adaptation, whereas Valais has so far done little to address adaptation to the impacts of climate change at the cantonal level. This difference was reflected in the interviews: all four projects were primarily embedded in the national pilot program and no cantonal agencies were directly involved in their development or implementation. Nevertheless, all the projects in Grisons profited from the work done by the cantonal level to sensitize local authorities to climate change adaptation. Project implementers in Grisons also received additional funding from cantonal agencies. Both factors were mentioned as important success factors for the projects several times. The project Acclimatasion, in contrast, received no support from the cantonal level. Despite their overall success, Acclimatasion implementers felt that they could have achieved much more progress in raising awareness for the issue beyond municipal borders with cantonal support. This demonstrates that support and a regulatory base provided by intermediate administrative levels are relevant factors even for implementation efforts that are already embedded in a national structure.

Finally, the two cases of Zurich and Biel that were not part of the national pilot program adaptation once again highlight its importance. Neither Zurich nor Biel received any direct input or support from higher administrative levels. Consequently, representatives from both cities cited the lack of directed mainstreaming and goal clarity as serious barriers to their efforts. The canton of Zurich has now begun to more seriously engage in climate change adaptation and is working closely together with civil servants from the city of Zurich and other municipalities in doing so. These efforts were recognized and praised by the representatives of the city. However, they also felt that they were too late to significantly support the city of Zurich in the development of their climate master plan. Representatives of the city of Biel complained that they had received no support whatsoever regarding climate change adaptation from the canton of Bern. Although they recognized the efforts of the federal offices to provide important information and policy roadmaps, they felt that these materials were mostly too broad to be directly applicable at the local level.

#### 14.7.3 Managerial mainstreaming

Managerial mainstreaming played a somewhat important role in both Zurich and Biel, where working structures within city agencies were modified to include adaptation goals. The most prominent example of managerial mainstreaming we identified, however, was not directly linked to one of our six local cases but rather to the implementation of the cantonal climate strategy Grisons. Grisons founded a cantonal climate secretariat to assist the cantonal agencies in the implementation of the cantonal climate strategy. Its responsibilities are mainly to assist agencies with administrative tasks such as the reporting of adaptation activities to the federal state, conducting awareness-raising activities, and organizing inter-organizational events. Although only one person staffs the climate secretariat, its efforts have been praised as an important success factor for the cantonal climate strategy by several interviewees. The person staffing the climate secretariat also played an important advisory role for two of the pilot projects taking place in Grisons.

A lack of managerial mainstreaming was identified as a barrier in the cases of Aquafutura, Toolbox Surselva, and Acclimatasion. All three projects struggled to some extent with not having an official contact responsible for climate adaptation at either the regional or cantonal level and had to contend with working with political stakeholders who had little interest in the topic of adaptation.

#### 14.7.4 Add-on mainstreaming

Add-on mainstreaming played a minor role overall, as new tasks and responsibilities were generally distributed among existing actors. However, the case of Acclimatasion demonstrates that the design and quick implementation of new, on-the-ground measures can have a powerful showcase effect, generating goodwill and increasing sensitization for adaptation among the populace. Thus, even

approaches that focus on integrating environmental policy goals into existing policies and measures and tasking existing actors with their implementation should not underestimate the value of small add-on measures that can serve as good practice examples.

## 14.8 Discussion

### 14.8.1 Inter-sectoral cooperation through cooperative mainstreaming

A central result of our empirical analysis is that Swiss government agencies across administrative levels have commonly chosen an approach that combines elements of inter-organizational and programmatic mainstreaming. Key to the success of this approach is to avoid traditional rivalries between sectors by avoiding steep hierarchies and having central agencies take on coordinating roles rather than leadership roles. We propose to call this approach cooperative mainstreaming because it focuses on cooperatively defining and assigning adaptation policies and responsibilities while avoiding conflicts between sectors. Cooperative mainstreaming ensures that representatives from all relevant governmental sectors are involved in defining adaptation goals and determining how they are to be integrated into the existing workload of the agencies involved. It is a consensual approach that in terms of the EPI literature focuses on ensuring consistency, coherency, and comprehensiveness (Persson et al., 2018; Underdal, 1980).

The inter-organizational exchange inherent in the cooperative mainstreaming process increases goal clarity as well as the governance skills and personal motivation of the representatives involved in the process. Goal clarity is increased because representatives together discuss the expected climate impacts, primary fields of action for adaptation, and respective responsibilities. Governance skills increase because representatives exchange important information with their peers and, as seen in the cases of Grisons and Sion, inter-sectoral exchanges often include adaptation-related training. Finally, the regular exchange increases personal motivation of the representatives, as peer pressure urges them to achieve at least some success. The prevalence of this strategy across our cases demonstrates the importance of collaborative policy making for successful implementation (Ansell et al., 2017; Hudson et al., 2019). Figure 3 shows our model of the causal mechanisms between mainstreaming strategies and implementation updated by the inclusion of cooperative mainstreaming.

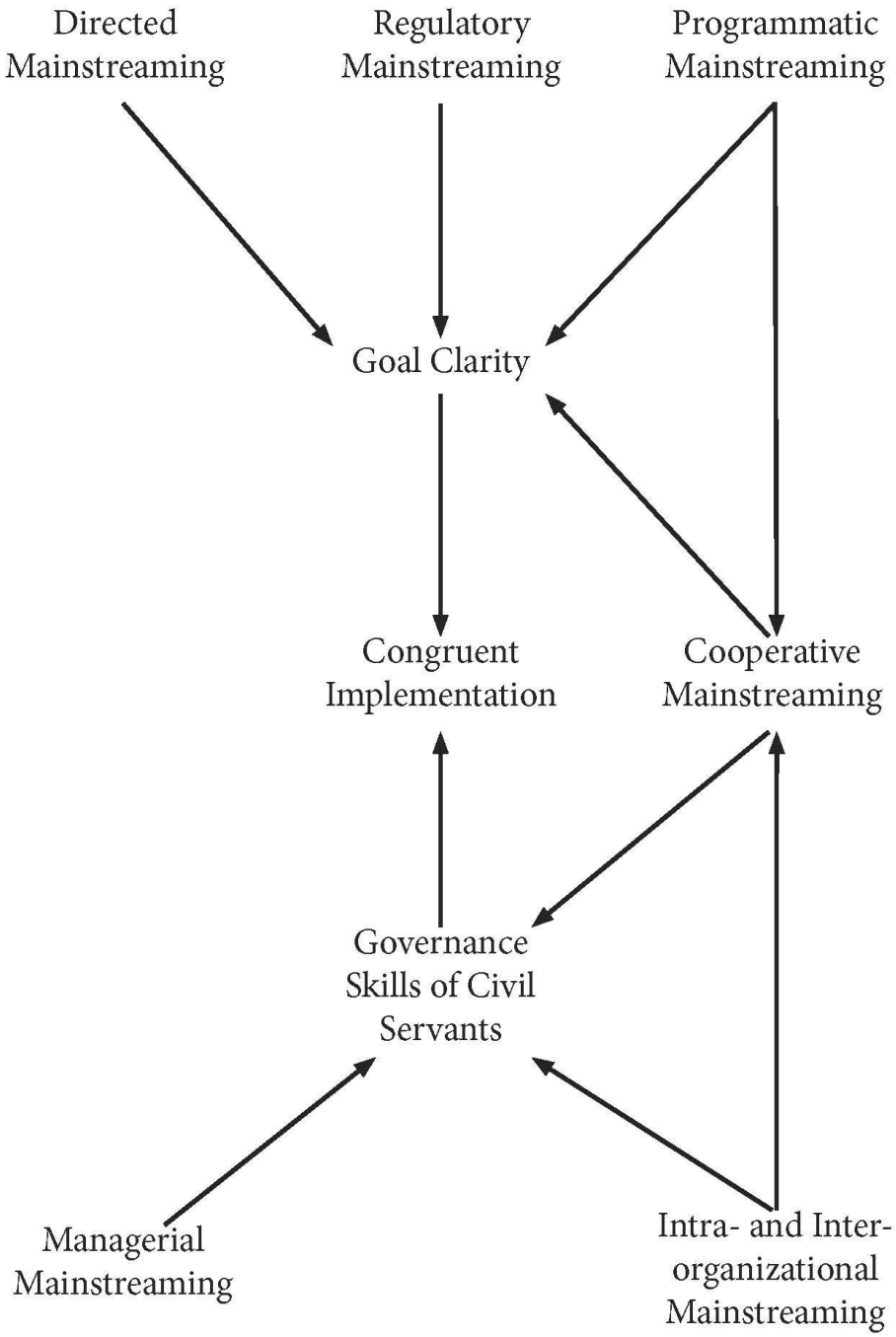


Figure 14-14-3: Updated causal mechanisms between mainstreaming strategies and implementation

### 14.8.2 Disadvantages of cooperative mainstreaming

The focus on cooperative mainstreaming also has its disadvantages. As the cases of Aquafutura, Toolbox Surselva, and Acclimatasion demonstrate, the overall lack of managerial mainstreaming has created some problems: without a clearly defined institution or person responsible for climate adaptation at the intermediate jurisdictional level, local stakeholders lacked an important contact point. Moreover, our interviews on the cantonal climate strategy Grisons have shown that the positive effect of the adaptation governance skills and personal motivation of the governmental stakeholders involved in the cooperative mainstreaming was rather limited in some cases. Disinterested department heads sent one of their subordinates in lieu of participating in the inter-sectoral exchange themselves. Non-environmental sectors such as the economic and agricultural sectors view climate adaptation as something that is nice to have rather than one of their core responsibilities. These issues line up almost perfectly with the possible disadvantages of mainstreaming discussed by Runhaar et al. (2018). Even environmental sectors do not give adaptation objectives priority over their traditional responsibilities. Although the focus on avoiding hierarchies between sectors aids in bringing everyone to the table, its flipside is that the coordinating agencies largely lack the means to force compliance from partners that only pay lip service to adaptation goals.

### 14.8.3 Inadequate goal clarity owing to a lack of directed and regulatory mainstreaming

Despite its disadvantages, cooperative mainstreaming has mostly been successful in promoting horizontal cooperation for adaptation. However, vertical cooperation is a different beast. Project stakeholders supported by the pilot program adaptation were generally satisfied with the direction and support provided. However, beyond participation in federally funded pilot programs, vertical integration in the form of directed mainstreaming is limited and regulatory mainstreaming even more so. Although they serve as an important source of information and legitimization for local adaptation, current national adaptation policies primarily aim to improve cross-sectoral integration at the national level. Thus, they formulate neither a clear mandate nor specific instructions for sub-national adaptation. The only legal mandate for sub-national adaptation obligates cantons to report their progress to the Federal Office for the Environment but does not formulate any concrete expectations on what this progress should look like. Consequently, lacking goal clarity is one of the major barriers to sub-national adaptation, as demonstrated by the case of Biel. Overall, the inadequate state of directed and regulatory mainstreaming leaves local adaptation largely dependent on the engagement of local stakeholders.

Perplexingly, many interviewees displayed a contradictory attitude toward regulatory mainstreaming. They praised existing policies such as the strategy for climate change adaptation by the federal council and complained about the lack of a sufficiently clear adaptation policy to provide guidance and define priorities. There was even a case of existing legislation directly hindering adaptation efforts. Nevertheless, interviewees were critical of the notion of introducing new legislation at the federal or cantonal level to formulate a clear mandate for municipalities to engage in climate change adaptation. Reasons given varied: political feasibility, adherence to the principle of subsidiarity, the difficulty of formulating a uniform mandate for a task that significantly differs in specifics between municipalities, or fear of an abundance of legislation crippling the capabilities of local governments. In general, the representatives of higher administrative levels seemed more open to the idea but doubted its political feasibility, whereas representatives of the local level outright rejected the idea.

It seems paradoxical: most interviewees agreed that clear policy guidelines and the institutionalization of adaptation goals were necessary to progress beyond insular successes. Nevertheless, everyone agreed that this necessary regulatory mainstreaming should or could not take the form of direct legislation. This indicates that higher levels should focus on directed mainstreaming strategies rather than regulatory mainstreaming. Despite universally complaining about the lack of resources, most local stakeholders do not necessarily expect the state or cantons to provide more money for adaptation; rather, they expect more accessible information on what to do. This apparent lack of goal clarity is certainly one reason why on-the-ground adaptation measures have so far been rare. In the absence of a clear mandate, a clearly defined goal, and specific instructions on how to achieve it, local adaptation has largely been dependent on local initiatives kicked off by extraordinarily motivated local stakeholders or extreme events.

#### 14.8.4 Overcoming the adaptation implementation gap through mainstreaming

Our results largely mirror previous insights from the adaptation mainstreaming literature and EPI literature in general. Adaptation mainstreaming focuses on avoiding incoherencies and contradictions through cross-sectoral coordination while the normative objective of prioritization is largely neglected (Widmer, 2018). This results in a lack of commitment to directed and regulatory adaptation mainstreaming from higher jurisdictional levels (Persson et al., 2018). In consequence, even wealthy states have trouble progressing from strategic declarations of overarching goals to concrete, on-the-ground measures (Jordan & Lenschow, 2009; Widmer, 2018), resulting in the adaptation implementation gap.

The advantage of our mainstreaming strategy framework and our focus on identifying causal mechanisms is that they allow us to determine how and why the lack of specific mainstreaming

strategies contributes to the adaptation implementation gap and to learn from those cases that best succeeded in overcoming said gap. The consequences of a lack of directed and regulatory mainstreaming are demonstrated across our cases but most clearly when comparing the cases in Grisons to the cases outside Grisons as well as when comparing pilot projects to non-pilot projects. Despite the lack of activity at the cantonal level in Valais, project Acclimatasion was generally considered a resounding success. One of the main reasons for the positive reception of the project is its success at realizing concrete win-win measures that served both adaptation and the beatification of the city. The showcase effect of these measures in turn increased political goodwill for adaptation and enabled the project stakeholders to push for the integration of adaptation goals into municipal planning policy. Although the personal motivation of the project leaders within the city administration remains an important factor, their success demonstrates a possible pathway for overcoming the adaptation implementation gap: directed mainstreaming to promote the realization of local, on-the-ground measures with benefits beyond adaptation can serve as an important tool to bring adaptation onto the local agenda and foster political support for adaptation measures. In this way, adaptation benefits from what Candel and Biesbroek (2016) call "natural coherence." Contrary to other environmental concerns, adaptation goals are often in line with traditional sectoral objectives, which simplifies the pursuit of win-win measures (Widmer, 2018). Such an approach would have the dual benefits of increasing goal clarity for local stakeholders while also increasing their motivation and granting them the opportunity to improve their adaptation governance skills through the implementation of concrete measures.

### 14.9 Conclusions

Adaptation in Switzerland has so far largely been limited to organizing inter-sectoral coordination at the national level and in some cantons and cities through a combination of inter-organizational and programmatic mainstreaming, which we call cooperative mainstreaming. Concrete, local adaptation measures have so far been sporadic (Braunschweiger et al., 2018; Widmer, 2018). Difficulties in progressing from coordination measures at higher levels to concrete, local measures are well-documented in EPI literature (Jordan & Lenschow, 2009). However, our framework and our attention to causal mechanisms allowed us to recognize a key factor contributing to this adaptation implementation gap in Switzerland: the lack of directed mainstreaming from higher jurisdictional levels results in uncertainty about adaptation goals and how to reach them at the local level. The project Acclimatasion demonstrates that this barrier can be overcome by promoting win-win measures to showcase the local benefits of adaptation via directed mainstreaming.

The important role that the hybrid strategy of cooperative mainstreaming played in our cases demonstrates that policy practice rarely perfectly conforms to ideal types formulated by frameworks such as ours. The value of the mainstreaming strategy framework lies in improving our understanding of how and why a lack of certain kinds of mainstreaming can become a barrier to adaptation or which type of mainstreaming is required to overcome a certain barrier. Although we focus on climate change adaptation mainstreaming, the framework, including our addition to it, is equally applicable to the policy integration of any other cross-cutting issues such as biodiversity management, disaster risk reduction, or gender equality.

One limitation of our paper is the question of how successful adaptation should be measured. How to measure the success of policy is a long-standing problem in the study of policy implementation, as policy outputs often do not completely determine outcomes and the outcomes themselves are much more difficult to measure. This problem is aggravated in the case of adaptation, where only few standards exist regarding what exact outcomes are to be expected in a case of successful adaptation. We overcome this problem by measuring the success of adaptation projects based on the judgement of the involved stakeholders that is reported in progress reports and during interviews. However, this may arguably not be an objective assessment, as stakeholders may overstate the success of their projects out of personal interest. Thus, we propose that future research aiming to improve our understanding of the implementation of adaptation may benefit from combining the insights of EPI and adaptation literature with approaches from the performance and conformance literature to assess the success of adaptation policy.

Although our empirical analysis focuses on the Swiss case, some of our results are applicable beyond national borders. Runhaar et al. (2018) conclude that the main reasons for the adaptation implementation gap are “a lack of a sustained political commitment for adaptation mainstreaming from higher levels, and the lack of effective cooperation and coordination between key stakeholders” (p. 1209). Switzerland has made important strides in promoting effective horizontal cooperation at the national level as well as in several cantons and cities through cooperative mainstreaming. Similar approaches could also be successful in other countries. However, the lack of directed mainstreaming resulting from a lack of political commitment at the national and cantonal levels remains problematic. Runhaar et al. (2018) suggest that stricter guidelines for mainstreaming at the national and international levels are necessary for adaptation mainstreaming to become more than a voluntary activity pursued only by highly motivated municipalities. Similarly, Bednar et al. (2019) conclude that more direct, hierarchical governance from the state level is necessary to mitigate the adaptation implementation gap. We propose that the impetus for national and intermediate levels to increase

their engagement in adaptation mainstreaming might also be generated bottom-up through the engagement of individual municipalities, as seen with the city of Zurich spurning the canton of Zurich to action. Nevertheless, if comprehensive progress is to be achieved, climate change adaptation cannot remain as dependent on the personal motivation and initiative of local stakeholders as it is today.

# 15 Cross-scale collaboration for adaptation to climate change - A two-mode network analysis of bridging actors in Switzerland

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## 15.1 Abstract

Adaptation to the impacts of climate change has become an increasingly important policy field in recent years, but it is complicated due to ambiguous responsibilities. To ensure the coherence of adaptation policies, cooperation is necessary between sectors as well as between administrative levels. As such, fragmentation between both sectors and levels is a huge challenge for the successful formulation and implementation of climate change adaptation policies. Bridging actors who coordinate actions across levels and sectors, play an important role in overcoming this challenge. Through means of social network analysis, I investigate which actors occupy key bridging roles in the multi-level and federalist arrangement of Swiss climate change adaptation governance. I analyse a two-mode network of actors and climate change adaptation measures, conducting a complete inventory of all measures and policies carried out in the context of the Swiss adaptation strategy as well as all actors involved in their design, funding and implementation. I find that federal governmental actors, occupy the most important bridging roles. However, for the most part, they seem more focused on building cross-sectoral ties than on building cross-level ties. The Swiss Federal Office for the Environment (FOEN) stands out as the one national authority that managed to establish almost as many cross-level ties as cross-sectoral ties through the coordination of an adaptation funding

programme. Thus, while adaptation measures will primarily be implemented on the municipal level, higher level actors still have a vital role to play in promoting municipal efforts, fostering collaboration and reducing fragmentation.

### 15.2 Keywords

Climate Change Adaptation; Governance; Environmental Policy; Social Network Analysis; Bipartite Networks; Bridging; Fragmentation

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Number of tables: 4

Number of illustrations: 2

Length of the manuscript (including tables and illustrations): 9104 words

## 15.3 Introduction

After decades of climate change mitigation efforts failed to constrain global greenhouse gas emissions to sustainable levels, many impacts of climate change are now inevitable or already happening (IPCC, 2018). Thus, adaptation efforts aimed at preparing for climate change impacts and reducing vulnerability to climate change have become increasingly important in recent years (Bauer et al., 2012). Climate change adaptation has emerged as a second, complementary field of policy to climate change mitigation in handling the climate crisis (Biesbroek et al., 2011). However, climate change impacts come in a broad variety that transcends the domains of traditional policy sectors and cuts across governmental levels. Thus, adaptation efforts must similarly transcend sectoral boundaries and administrative levels. This poses a significant challenge from a governance perspective, as different institutions share overlapping responsibilities or work independently on connected issues (Jasny & Lubell, 2015). Such interdependencies can be problematic, as governing bodies may fail to take into account how their actions affect other actors during decision-making processes (Jasny & Lubell, 2015). Furthermore, when multiple actors are involved in efforts to provide a service or protect a resource without clearly defined jurisdictions, collective action problems can quickly become system-threatening (Berardo, 2014; Feiock, 2009; Rhinard, 2013). As such situations may enable free-riding, individual actors may adopt non-cooperative strategies, rather than allowing themselves to be taken advantage of (Berardo, 2014; Feiock, 2013). Consequently, institutional fragmentation and the problems resulting therefrom have been identified as some of the most important barriers to adaptation (Biesbroek et al., 2011; Ekstrom & Moser, 2014).

Fragmentation is also directly related to another major barrier to adaptation: uncertainty. Climate change and its impacts are incredibly complex issues surrounded by many uncertainties. Actors are subject to uncertainties about exact climate change impacts and uncertainties about human handling of and reactions to climate change as well as uncertainties about the extent of human knowledge on climate change (Biesbroek et al., 2011). Many of these uncertainties are caused or exacerbated by fragmentation issues, such as a lack of institutionalised channels of exchange between relevant actors, insufficient exchange of information or a disconnect amongst the expectations of different actors. For example, Kiem and Austin (2013) find a significant gap between ‘the information that end-users need (or think they need)’ (p. 29) in rural Australia and the information produced by existing research on climate change impacts and adaptation.

Brokerage institutions reduce the challenges posed by fragmentation and uncertainties by connecting different actors and institutions, providing opportunities to negotiate terms of coordination and

distributing information (Berkes, 2002; Carlsson & Sandström, 2007; Crona & Parker, 2012; Jasny & Lubell, 2015). Brokers spread information and facilitate cooperation amongst actors who otherwise lack either access to one another or trust in each other (Marsden, 1982). Brokerage may also pave the way towards more collaborative governance approaches and thus reducing the odds of policy failure (Ansell et al., 2017).

The advantages provided by brokerage are widely recognised (Carlsson & Sandström, 2007; Crona & Parker, 2012; Stovel & Shaw, 2012; Tanaka et al., 1980) and many institutions aiming to function as brokers for various aspects of environmental policy have evolved in recent decades (M. Schneider et al., 2003). Specific instances of brokerage, sometimes also called bridging, are the subject of many empirical investigations (Aldrich & Herker, 1977; Brown, 1998; Chaskin, 2001; Collins-Dogrul, 2012; Friedman & Podolny, 1992; Hahn et al., 2006). Identifying which actors or which types of actors are most likely to take on such bridging roles in natural resource governance allows for targeted measures to support key bridging actors in their endeavours (Angst et al., 2018; Vignola et al., 2013). Thus, identifying important bridging actors in adaptation governance may contribute to overcoming key barriers to adaptation, such as fragmentation and uncertainty. My analysis aims to identify which actors take on bridging roles in adaptation governance based on the case of the Swiss federal strategy and action plan for adaptation to climate change. My goal is to answer the following two research questions:

1) *Which actors take on bridging roles amongst different sectors regarding adaptation to climate change?*
2) *Which actors take on bridging roles amongst administrative levels regarding adaptation to climate change?*

Today's political challenges are mostly cross-sectoral and multi-level in nature. One way to overcome such challenges is through key actors who take on bridging roles between different sectors and administrative levels. By answering these research questions, I contribute to the brokerage literature and the multi-level governance literature by applying established conceptualizations of brokerage to pinpoint those actors that bridge boundaries between different sectors and administrative levels. Thereby reducing fragmentation at two of its main sources, particularly when it comes to multi-level challenges such as adaptation to climate change. This is particularly relevant in the case of the federalist Swiss political system that delegates a lot of power and responsibilities to the subnational levels (Ladner, 2010) exacerbating the detrimental effects of fragmentation. Switzerland is also highly vulnerable to the impacts of climate change (Brönnimann et al., 2014) while simultaneously boasting high adaptive capacity due to its wealth and technological capacities (Westerhoff et al., 2011).

Nevertheless, climate change adaptation in Switzerland has so far been largely limited to strategic mainstreaming activities at the federal level while concrete adaptation at the municipal level is rare (Braunschweiger & Puetz 2021, Widmer 2018). This study aims to contribute to the resolution of this adaptation implementation gap by identifying important actors to support in their adaptation brokering endeavours. These results may also be relevant beyond the Swiss case for other wealthy industrialized countries subject to similarly lacking implementation of concrete adaptation measures (Dupuis & Knoepfel, 2013).

Methodologically, the paper contributes to the literature by showing how established operationalizations of different types of bridging actors may be applied to the analysis of two-mode network data. Empirically, I provide new insight into the governance of the highly fragmented field of Swiss climate change adaptation policy.

I first lay out the relevant theory and analytical framework for the paper by discussing climate change adaptation and the importance of bridging actors therein through the lens of the multilevel and polycentric governance framework as well as the literature on collaborative governance. From this framework and the literature discussed, I derive three hypotheses regarding the distribution of bridging positions and test them using social network analysis. I find that national level authorities as well as research institutions take on the most important bridging roles but national authorities generally focus on building cross-sectoral ties rather than cross-level ties.

## 15.4 Theory and analytical framework

Adaptation to anthropogenic climate change entered international and domestic policy agendas in recent decades as a consequence of both rising climate change impacts and the gradually spreading realisation that climate change mitigation efforts will most likely fail to completely prevent further escalation of said impacts (Bauer et al., 2012). Some researchers conceptualize adaptation to climate change as merely a new policy issue or even an increased focus on existing issues such as natural hazard management (Birkmann & Mechler, 2015; Leitner et al., 2020). However, while Switzerland has a long history of managing adaptation relevant issues such as flood prevention (Ingold & Gavilano, 2020), comprehensive national adaptation policies have only begun development in the last thirteen years (Braunschweiger et al., 2018). Based on their assessment of governmental and non-governmental actors concerned with adaptation as well as the number of sectors covered by the national adaptation strategy and action plan Massey and Huitema (2016) classify adaptation to climate change in Switzerland as a newly emergent policy field.

Different types of uncertainty are one of the main barriers to adaptation: Substantive uncertainties stem from the inherent complexity of anticipating and preparing for climate change impacts as well as uncertainties about how humans will handle climate change. They are exacerbated by strategic uncertainties stemming from the unique perceptions and strategies of individual actors and by institutional uncertainties stemming from the different institutional backgrounds of the actors involved (Koppenjan et al., 2004). Fragmentation between actors exacerbates these uncertainties as it impedes them in anticipating how others will behave and in comprehending their interpretations of human-environment relations, their strategies and their institutional guidelines (Ingold et al., 2019). However, uncertainty also stems from the lack of established substantive expertise due to the novelty of the field (Massey & Huitema, 2013, 2016). As such, the development of said expertise should be a priority during the early stages of adaptation policy. Indeed, there is ample empirical evidence that the development and communication of knowledge is a cornerstone of current adaptation policy in Europe (Bauer & Steurer, 2015; Biesbroek et al., 2010; Braunschweiger et al., 2018; Massey & Huitema, 2016). Brokers are of key importance to reduce these issues of fragmentation and uncertainty, to distribute knowledge among relevant actors and to coordinate adaptation measures. However, current adaptation literature is vague on which actors exactly are taking on this vital role.

### 15.4.1 Climate change adaptation - A multi-level governance challenge

Adaptation to climate change is also a multi-level challenge. While climate change is a global development, its impacts vary drastically, and adaptation needs vary accordingly across regional and local levels (Bauer & Steurer, 2014). Thus, municipalities and other actors at subnational levels are commonly expected to take charge of the design and implementation of concrete adaptation measures while national and supranational level actors raise awareness, conduct basic research, disseminate knowledge and provide funding and guidance (Galarraga et al., 2011; Keskitalo, 2010). Additionally, since climate change adaptation concerns private business and individuals as well, governmental actors are expected to facilitate exchanges with and between non-state actors (Cimato & Mullan, 2010) . Thus, effective adaptation governance must be able to bridge the gap between administrative levels as well as governmental and non-state actors (Adger et al., 2005; Bauer & Steurer, 2014). A multi-level governance system capable of addressing complex, long-term problems such as climate change must transfer power from central governments to local governments and from governmental to non-state actors to allow room for the growth of local initiatives while also fostering networks to improve coordination and disseminate information on best practices (Di Gregorio et al., 2019; Underdal, 2010). The multi-level governance framework thus clearly states the importance of bridging actors who serve these functions in adaptation governance networks.

Recognizing the multi-levelled nature of climate change adaptation challenges, most member states of the Organisation for Economic Cooperation and Development (OECD) are trying to reach adaptation goals by integrating them into the mandates and duties of those pre-existing state departments and agencies that are most closely affected by climate change impacts (Bauer & Steurer, 2015; Eisenack et al., 2014). Thus, adaptation policy is a prime example of polycentric governance (Ostrom, 2010). Polycentric governance arrangements where actors engage in simultaneous collective decision-making processes regarding interconnected issues force actors to 'learn, coordinate and cooperate' (Berardo & Lubell, 2019, p. 11). Systems that encompass ties to connect distant actors allow their members to quickly learn about new information or outstanding issues within the network (Berardo & Scholz, 2010). Thus, bridging actors are an important facilitator of learning in addition to coordination. Berardo (2014b) and Bodin et al. (2017) show, that actors belonging to more heterogenous networks are better able to learn and share information on how to handle complex problems. It follows that bridging configurations are of key importance to climate change adaptation governance systems, as climate change adaptation is an emergent policy field with actor constellations and policy guidelines still in flux across all administrative levels (Braunschweiger & Pütz, 2021).

### 15.4.2 Improving climate change adaptation through collaborative governance

The importance of bridging actors for climate change adaptation is also reflected in the literature on collaborative governance. Collaborative governance approaches play an important role in the resolution of so-called wicked societal problems such as climate change. They offer better coordination amongst governmental authorities (Bingham & O'Leary, 2014; Emerson & Gerlak, 2014) as well as improved public participation and stakeholder involvement (Leach & Sabatier, 2005). Collaborative governance enables political adversaries to find common ground, enables governmental actors to develop constructive relationships with non-governmental stakeholders and allows for advanced forms of collective learning and problem-solving (Ansell & Gash, 2007). Multi-actor collaboration during both the policy design and policy implementation phases reduces the odds of policy failure significantly (Ansell et al., 2017). Collaborating with the actors who are directly involved in and affected by the implementation of a policy allows important knowledge to be shared during the policy design process and helps to generate the political and administrative support necessary to ensure successful implementation (Ansell et al., 2017; Terman & Feiock, 2015). Collaborative policy design also 'facilitates a joint exploration of policy problems' (Ansell et al., 2017, p. 476) by fostering mutual trust between the actors involved and enabling them to develop new and creative policy solutions together. Collaboration continues to play an important role during the policy implementation process, as ongoing communication between policymakers and implementers allows policies to be updated and adapted to emerging problems and opportunities as well as local and regional conditions (Ernstson et

al., 2010; Hartley et al., 2013; McAllister et al., 2014; Pahl-Wostl, 2009; Torfing, 2019; Vignola et al., 2013). This substantiates the importance of bridging actors, who are necessary for collaboration to happen in the first place.

### 15.4.3 Types of bridging actors

Social network researchers differentiate between different types of bridging actors. Berardo and Scholz (2010) identify central coordinators as an important source of bridging capital. The idealised version of the central coordinator forms the centre of a star-structured network where every other actor is connected to him and only him. This way, the shortest path between any two members of the network will always go through the central coordinator, making them integral for efficient coordination. Of course, idealised versions of central coordinators rarely exist in practice, but some form of core-periphery structure has been observed in many empirical studies, demonstrating the importance of the role (Ernstson et al., 2010; Hirschi et al., 2013; Luthe et al., 2012). Others specifically analyse actors that form bridging ties across levels (Rathwell & Peterson, 2012), actor types (McAllister et al., 2015) or ecological scales (Ernstson et al., 2010). Angst et al. (2018) propose a classification building on the two strengths of bridging ties that Berardo and Scholz (2010) identify: distribution of knowledge and coordination. They discuss two types of bridging ties that contribute to these strengths in slightly different ways: central coordinators and periphery connectors.

Central coordinators form connections to many others and represent the shortest path between many other pairs of actors that are not directly linked. They are thus very valuable when coordination needs to be strengthened or when information needs to be disseminated across the network as efficiently as possible. Periphery connectors, on the other hand, connect actors to the network that have no other connection to it. Thus, they increase the heterogeneity of the network and its access to non-redundant information and increase its capacity for learning.

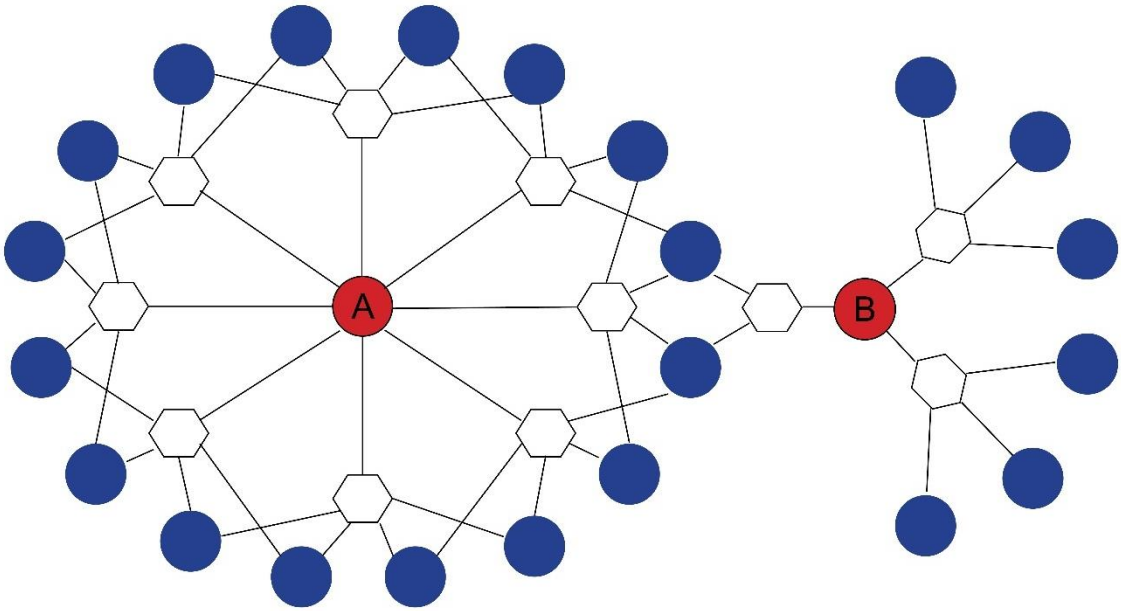


**Figure 15-1: Illustration of Central Coordinator Position (A) and Periphery Connector Position (B) in a bipartite network (actors are represented as circles, and policies and measures are represented as hexagons).**

## 15.5 Hypotheses

The literature on polycentric and collaborative governance emphasises that both governmental and non-governmental actors form important, independent decision-making entities at different scales (Ostrom, 2010, 2014). As their respective decisions affect one another, actors in such governance systems develop mechanisms to coordinate their actions, to cooperate and to resolve conflicts. But which actors are most likely to take on bridging positions? As Fliervoet et al. (2016) explain, collaborative governance may be a shift away from traditional conceptions of hierarchical governance, but governmental actors still have important roles to play. Governmental actors generally have the highest capacity for coordination and facilitation and may thus be more likely to occupy bridging roles. While Berardo and Lubell (2016) contend that governmental actors generally have more resources available to participate in policy forums and build ties than non-governmental actors. Similarly, Klijn & Koppenjan (2000) show how governmental actors are uniquely capable of coordinating networks even in polycentric governance settings by engineering venues for interactions and strategically allocating government resources. Ingold et al. (2017) also show that governmental actors may be more likely to play important coordinating roles especially in nascent policy subsystems. When actors are yet uncertain about their policy preferences, allies and enemies, formal decision makers or structurally

particularly well-embedded actors serve as important role models and knowledge providers. This brings me to my first hypothesis:

> Hypothesis 1: Governmental actors are more likely to take on cross-level and cross-sectoral bridging roles than non-governmental actors.

In a similar vein, it can be argued that national authorities generally have more resources at their disposal and greater capacities for coordination and facilitation than their subnational counterparts. Angst and Hirschi (2017) argue that higher level governmental actors play important bridging roles due to their superior ability to build stable and long-lasting ties. Angst et al. (2018) show that higher level governmental actors are more likely to take on bridging roles than their counterparts at the municipal level since their activities typically encompass a broader range of actors. This leads me to my second hypothesis:

> Hypothesis 2: Higher level governmental actors are more likely to take on cross-level and cross-sectoral bridging roles than lower level governmental actors.

These hypotheses are in line with the current state of research: Swart et al. (2009) find that coordinating actors, organising the development and distribution of knowledge and coordinating sectoral activities for climate change adaptation in Europe are usually governmental actors. Lorenz et al. (2019) show that most key climate change adaptation actors in the UK are governmental actors. National level authorities dominate the top 10% of the ranking, demonstrating how responsibility for climate change adaptation has been spread amongst sectors and that national authorities play important coordinating roles. Multiple studies on Swiss climate change adaptation governance also found the FOEN to occupy an important central coordinator role (Christopoulos & Ingold, 2015; Braunschweiger et al., 2018; (Braunschweiger & Pütz, 2021)

Lastly, due to the nature of climate change adaptation as an emergent policy field and the many uncertainties surrounding it, I expect adaptation actors to seek ties to actors capable of reducing said uncertainties by producing and disseminating knowledge. Thus, I expect research organisations to play a central role during these early stages of adaptation policy, as suggested by an early assessment of the state of adaptation in Europe (Swart et al., 2009). With various heterogeneous actors poised to seek out knowledge, large research organisations are perfectly positioned to take on bridging roles amongst their different clients.

> Hypothesis 3: Research organisations are more likely to take on cross-level and cross-sectoral bridging roles than other non-governmental actors.

## 15.6 Case, data collection and method of analysis

### 15.6.1 The case of climate change adaptation in Switzerland

Many longstanding policies and measures exist across different sectors, such as natural hazard management, water governance, forest management or agriculture that increase resilience to the impacts of climate change. However, policies and measures that explicitly and primarily aim to adapt to climate change have only started appearing during the last decade (Braunschweiger et al., 2018; Kruse & Pütz, 2014). The field is also subject to heavy fragmentation as different climate change impacts fall under the purview of different sectoral authorities (Bauer et al., 2012). This fragmentation is further exacerbated in the case of Switzerland, with its federal system that delegates a large amount of political authority and responsibility to the subnational cantonal and municipal levels (Ladner, 2010). In Switzerland, national climate change adaptation policy began in 2008 with the foundation of the interdepartmental climate committee, which aimed to coordinate the activities of all the federal agencies involved in climate politics, including adaptation. The work of the committee resulted in the creation of the Swiss adaptation strategy of the federal council in 2012 and its second part, the national action plan adaptation, in 2014 (Widmer, 2018). The strategy is primarily meant to foster inter-sectoral cooperation regarding climate change adaptation at the federal level, while the action plan defines 63 measures to implement the strategy (Braunschweiger & Pütz, 2021). The action plan has since been reworked, and an updated version was released in 2020. One of the more prominent measures contained within the action plan is the pilot programme adaptation, which sponsored 31 adaptation projects on the cantonal and municipal level. The pilot programme is significant in so far as it marks the national level adaptation policies' first departure from the exclusive focus on federal agencies and instead aims to foster initiatives on the subnational levels (Braunschweiger & Pütz, 2021). The legal basis for Swiss climate change adaptation is the CO2-law, which mandates the FOEN to coordinate adaptation measures while accounting for the measures of the cantons. The cantons are mandated to report to the FOEN on their adaptation measures. This lack of a clear legal adaptation mandate for cantons or municipalities has lead to very heterogenous adaptation progress at the subnational level (Braunschweiger & Pütz, 2021).

### 15.6.2 Data collection

My data collection process began with an expert workshop attended by the members of the INTERREG (European Territorial Cooperation) project GoApply [1], which aimed to analyse climate change adaptation governance in the Alpine space. The project team included both scientists and members of

[1] https://www.alpine-space.org/projects/goapply/en/home

the federal administrations from the four Alpine countries Austria, Germany, Italy and Switzerland (a full list of participants can be found in the annex). Workshop attendees worked together to identify the most important climate change adaptation policies, measures and actors in all four countries. I started the analysis by reviewing all publicly available documentation and progress reports on the Swiss adaptation policies and measures identified during the workshop (a full list of all reviewed documents can be found in the annex). I reviewed these documents for information on any actors mentioned as being involved in the design, the implementation or the financing of said policies and measures. Strategic policy documents usually mentioned the actors responsible for their design while documents more directly concerned with implementation such as action plans or project reports usually mentioned who would be responsible for the implementation process. This is how I identified the actors included in my network analysis. If policy documents mentioned any subsequent policies or measures deriving from or involved in the implementation of the superordinate policies and measures, I continued by finding any available documentation on those subordinate policies and measures and likewise analysing them. The collection of policies and measures identified through this process form the second mode of my network. I only included policies and measures explicitly defined as pertaining to climate change adaptation. This data was then validated based on 24 interviews with members of the federal, cantonal, and municipal administrations as well as employees of NGOs and private companies involved in the implementation of adaptation measures. Documentation on any additional policies and measures identified during these interviews was likewise analysed. Through this process, I identified 125 actors involved in the design, financing, or implementation of a total of 110 adaptation policies and measures included in or derived from the Swiss national adaptation strategy. These policies, measures and actors form the nodes of my network. Actors are tied to all the policies and measures they were involved in.

The data collection process took place from July 2017 to April 2018. It included documents starting in 2018 and dating back to 2009, although most analysed documents were published after the adoption of the national adaptation strategy in 2012.

### 15.6.3 Method of analysis

My data structure links actors with all the policies and measures that they were involved in rather than directly with each other. In network analysis, this type of data is called two-mode data. Nodes belong to one of two groups or modes, and ties always connect two nodes that do not belong to the same group (Thiétart et al., 2012). I considered policies and measures as one group of nodes and actors as the second group. I consider two actors to have co-participated in a policy or measure if they share a direct tie to at least one policy or measure.

Two-mode data can be analysed either by converting the data into one-mode data or representing two-mode data in a bipartite network (Thiétart et al., 2012). However, conversion to one-mode data leads to a loss of information on the original structure of the dataset (Borgatti & Everett, 1997). For example, if I was to convert my data, I would no longer be able to retrace which policies and measures had played an especially important role as they established a markedly high number of ties between actors or connected actors that had not worked together on any other policies and measures. While this disadvantage can be avoided by employing a dual-projection conversion approach (Everett & Borgatti, 2013), such an approach would be just as complex as working with bipartite networks. The primary disadvantage of working with bipartite networks is that the methods employed to calculate certain characteristics need to be adjusted or may not be applicable at all. Thus, whether I follow a conversion approach or not depends on how I operationalize bridging actors and whether those operationalisation methods can be applied to two-mode networks or not.

The analysis of two-mode data rests on the assumption that co-participation in a policy or measure by two actors is comparable to the direct ties measured by one-mode network analysis. However, Borg et al. (2015) validated this assumption by showing that ties of trust between actors are primarily established through working together rather than exchanging information or sharing common goals.

A common indicator for the centrality of an actor is betweenness centrality (Christopoulos & Ingold, 2015; Freeman, 1977; Ingold, 2011). Betweenness centrality measures how often any given node in a network lies on the shortest possible path between two other nodes, indicating how well-positioned said actor is to take on a coordinating role within the network (Borgatti & Everett, 2006; Thiétart et al., 2012). Betweenness centrality can be calculated for two-mode networks by following the method introduced by Borgatti and Everett (1997). Thus, following Angst et al. (2018) who first proposed to categorize bridging actors as central coordinators and periphery connectors, I operationalise central coordinators by calculating the betweenness centrality for all actors and identifying those actors that show the highest results.

Periphery connectors connect actors to the network that have little or no other connection to it. As the method employed to identify periphery connectors by Angst et al. (2018) is not well suited for analysing two-mode networks, I instead use network modularity to operationalise periphery connectors. Network modularity is an indicator of the extent to which a network is divided into separate modules or clusters. Higher modularity indicates more dense connections between actors within the same module but less well-developed connections between different modules (Guimerà & Amaral, 2005; Newman, 2006; Olesen et al., 2007). Thus, the removal of a periphery connector from the network results in higher modularity as connections between separate modules disappear with

them. Whereas for more peripheral actors, their removal from the network results in lower network modularity as the separate modules they form disappear with them and the remaining modules are on average more well-connected than before. For any given actor, I calculate the difference in modularity between the network without that actor and the original network. Any actor whose removal leads to an increase in network modularity is considered a periphery connector. This new method of identifying periphery connectors allows for more nuanced assessments of how the presence or absence of specific nodes influences the heterogeneity of a network and is easily applicable to two-mode as well as one-mode networks.

I calculate betweenness centrality scores and modularity scores using the R packages statnet (Handcock et al., 2008) and igraph (Pemberton, 1975). Arguably, all actors with a betweenness centrality score above zero are coordinators, as they constitute the shortest path between at least two other actors. However, I am specifically interested in those actors playing the most important coordinating roles within the network. Thus, I consider actors central coordinators if their betweenness centrality scores lie both above zero and within the top ten percent of betweenness scores.

Each actor in the network is assigned two variables denoting the administrative level and the sector to which they belong as shown in tables 15-1 and 15-2. Governmental actors are assigned to the federal, cantonal, or municipal level depending on their level of jurisdiction while profit oriented private business are assigned to the private sector. The remaining non-state, non-private actors such as research institutions or non-profit organizations (NPO) are assigned the label miscellaneous. Sectoral affiliations are assigned based on official designation for state actors, based on the closest fit of their primary product or service for private businesses or based on my assessment of their thematic focal point in the case of non-profit organization. For each identified bridging actor, I then calculate the total number of co-participants operating at different administrative levels (cross-level ties) and from different policy sectors (cross-sectoral ties).

| **Administrative Level** | **Number of Actors** |
|---|---|
| Federal | 36 |
| Cantonal | 33 |
| Municipal | 8 |
| Private Sector | 14 |
| Miscellaneous | 34 |
| Total | 125 |

**Table 15-1: Distribution of actors in the network across administrative levels**

| Sector | Number of Actors |
|---|---|
| Agriculture | 10 |
| Construction | 3 |
| Economy | 10 |
| Energy | 3 |
| Environment | 33 |
| Health | 2 |
| Hunting | 1 |
| Meteorology | 1 |
| Military and Civil Protection | 5 |
| Natural Hazards | 9 |
| Research | 24 |
| Spatial Planning | 3 |
| Traffic & Transport | 5 |
| Water | 11 |
| Miscellaneous | 5 |
| Total | 125 |

Table 15-2: Distribution of actors in the network across policy sectors

## 15.7 Results and Discussion

Figure 15-2 shows the climate change adaptation actor network in Switzerland. As is immediately apparent, the FOEN plays an extremely important coordinating role with a betweenness centrality score that is almost five times as high as that of the runner-up. The federal offices involved in the design and implementation of the adaptation strategy, as well as their primary partners at the cantonal level, form a core structure with well-developed ties amongst each other. Municipal and non-governmental actors largely form various peripheral clusters. Similar core-periphery structures have been recognised in many empirical studies of natural resource governance networks (Angst et al., 2018; Ernstson et al., 2008; Hirschi et al., 2013; Luthe et al., 2012). One small cluster around the municipal adaptation strategy for Zurich turns out not to be connected to the overall network.

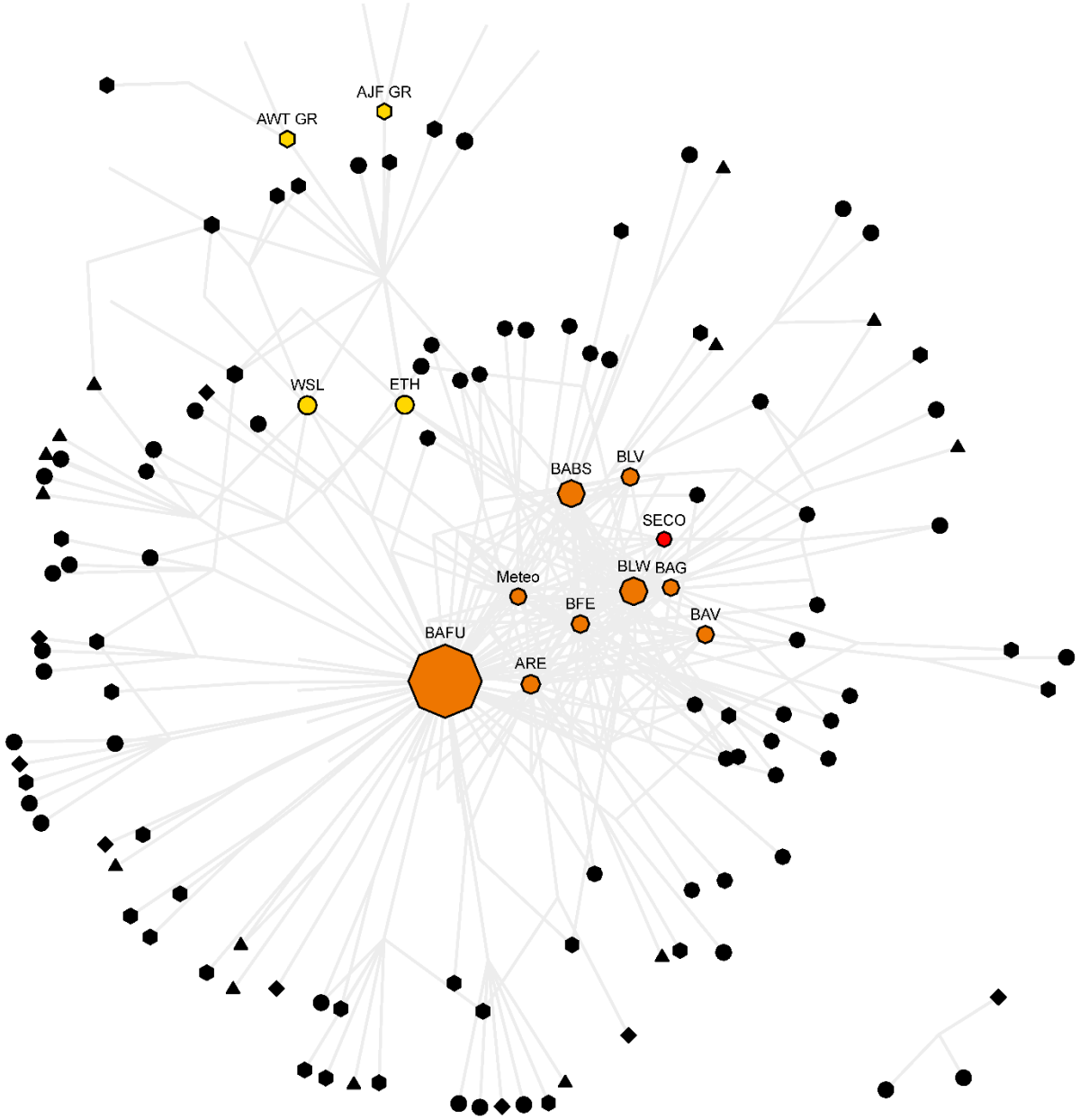


**Figure 15-2: Climate change adaptation actor network in Switzerland and important bridging actors - Federal actors are visualised by octagons, cantonal actors by hexagons, municipal governmental actors by quadrangles, private businesses by triangles and miscellaneous actors such as research institutions or NPOs by circles. Vertex size correlates to betweenness centrality. Important bridging actors are labelled and marked by colour: Central coordinators in yellow, periphery connectors in red and actors that fulfil both roles in orange. Policies and measures are not pictured to improve visual clarity**

### 15.7.1 Distribution of bridging positions

Out of 125 actors, three were eliminated from the analysis, as they have no connection to the larger overall network. Amongst the remaining 122, I identified thirteen central coordinators and ten periphery connectors. Table 15-3 details how bridging positions are distributed amongst

administrative levels as well as amongst governmental and non-governmental actors. Most central coordinators are governmental actors, with the two exceptions being a federally funded university and research institution, respectively. The federal authorities are very well represented amongst central coordinators, making up nine out of thirteen of them, with the FOEN, the Federal Office for Agriculture (FOAG) and the Federal Office for Civil Protection (FOCP) occupying the three most prominent coordinating roles. The last two central coordinator positions are occupied by the cantonal agency for the Economy and Tourism (AWT) as well as the cantonal agency for Hunting and Fishing (AJF) Grisons.

Periphery connector positions are exclusively occupied by federal level authorities. This may be evidence of the fact that governmental actors are more inclined to seek out new information than non-governmental actors. Nine out of ten identified the periphery connectors are also central coordinators, while nine out of thirteen central coordinators are also periphery connectors. This degree of overlapping between the two bridging types is yet more evidence of the important bridging and coordinating roles the federal authorities play in the governance of adaptation to climate change in Switzerland.

| **Actor attributes** | **Central coordinators** | **Periphery Connectors** |
|---|---|---|
| Federal Level | 9 | 10 |
| Cantonal Level | 2 | 0 |
| Municipal Level | 0 | 0 |
| Private Sector | 0 | 0 |
| Miscellaneous | 2 | 0 |
| Total | 13 | 10 |

**Table 15-3: Distribution of bridging positions across administrative levels as well as governmental and non-governmental actors**

| Actor | Administrative Level | Ties | Cross-level Ties | Cross-sector Ties | Cross-level Ties [%] | Cross-sector Ties [%] | Betweenness Centrality (scaled) | Delta Modularity | Central Coordinator | Periphery Connector |
|---|---|---|---|---|---|---|---|---|---|---|
| Federal Office for the Environment | Federal | 97 | 62 | 68 | 63.92 | 70.10 | 10.512 | 0.0824 | 1 | 1 |
| Federal Office for Agriculture | Federal | 47 | 15 | 40 | 31.91 | 85.11 | 2.198 | 0.0303 | 1 | 1 |
| Federal Office for Civil Protection | Federal | 40 | 16 | 36 | 40.00 | 90.00 | 2.083 | 0.0149 | 1 | 1 |
| Federal Office for Spatial Planning | Federal | 36 | 9 | 35 | 25.00 | 97.22 | 0.610 | 0.0256 | 1 | 1 |
| Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) | Misc. | 26 | 18 | 16 | 69.23 | 61.54 | 0.444 | -0.0160 | 1 | 0 |
| Swiss Federal Institute of Technology Zurich (ETH) | Misc. | 30 | 23 | 25 | 76.67 | 83.33 | 0.424 | -0.0187 | 1 | 0 |
| Swiss Federal Office of Energy | Federal | 32 | 4 | 31 | 12.50 | 96.88 | 0.392 | 0.0138 | 1 | 1 |
| Federal Food Safety and Veterinary Office | Federal | 24 | 6 | 22 | 25.00 | 91.67 | 0.368 | 0.0106 | 1 | 1 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Federal Office of Transport | Federal | 25 | 5 | 23 | 20.00 | 92.00 | 0.295 | 0.0019 | 1 | 1 |
| Office for the Economy and Tourism Grisons | Cantonal | 13 | 5 | 13 | 38.46 | 100.00 | 0.248 | -0.0105 | 1 | 0 |
| Federal Office of Public Health | Federal | 22 | 4 | 22 | 18.18 | 100.00 | 0.185 | 0.0042 | 1 | 1 |
| Federal Office of Meteorology and Climatology | Federal | 32 | 6 | 32 | 18.75 | 100.00 | 0.176 | 0.0193 | 1 | 1 |
| Office for Hunting and Fishing Grisons | Cantonal | 12 | 5 | 12 | 41.67 | 100.00 | 0.109 | -0.0111 | 1 | 0 |
| State Secretariat for Economic Affairs | Federal | 17 | 3 | 15 | 17.65 | 88.24 | -0.107 | 0.0043 | 0 | 1 |

**Table 15-4: Identified bridging actors and their respective proportions of cross-level and cross-sectoral ties**

### 15.7.2 Cross-level and cross-sectoral ties of bridging actors

Due to the high amount of overlap between central coordinators and periphery connectors, I identified only fourteen unique bridging actors in total. Table 15-4 shows all bridging actors with their respective betweenness centrality and delta modularity scores, whether they are central coordinators or periphery connectors or both, their number of ties to other actors and their respective proportions of cross-level ties and cross-sectoral ties.

Overall, I observe considerably more cross-sectoral ties than cross-level ties. The reasons for this are two-fold. Firstly, there is a lot more variation regarding policy sectors than there is regarding administrative level. Secondly, the Swiss adaptation strategy primarily aims to improve inter-sectoral cooperation at the federal level. This is readily apparent in the scores of the federal offices, which mostly boast proportions of cross-sectoral ties from 85–100% but cross-level proportions below 40%, and in many cases even below 20%. The one exception to this trend amongst federal offices is the FOEN with 64% cross-level ties and 69% cross-sectoral ties. Presumably, the reason for this deviation is that the FOEN takes on a coordinating role amongst federal offices for the adaptation strategy and action plan in general and, in particular, for the pilot programme adaptation, which aims to foster adaptation initiatives at subnational levels. This special role of the FOEN is also reflected in its high number of ties in general and its betweenness centrality score.

In addition to the ten federal offices, I find that two cantonal offices, the AWT and the AJW, as well as two research institutions, the ETH and the WSL, also play important bridging roles. The fact that two cantonal offices from Grisons occupy bridging roles demonstrates the progress achieved by the cantonal climate strategy Grisons. Said strategy mirrors the federal adaptation strategy insofar as it primarily aims to foster intersectoral coordination within the canton. This is reflected by the fact that both cantonal offices established considerably more cross-sectoral ties than cross-level ties. The two research institutions on the other hand show remarkably high proportions of cross-level ties with 76.67% and 69.23% respectively surpassing even the FOEN.

I hypothesised that higher level actors and governmental actors are more likely to take on both cross-level and cross-sectoral bridging roles. The network contains a total of 122 actors. Forty-four out of those 122 are federal level actors, and 58 are governmental actors. Thus, if bridging role distribution were independent from administrative level or governmental status and, federal level actors should make up 30–40% of bridging roles and governmental actors should make up 45–55% of bridging roles.

I find that amongst a total of fourteen identified bridging actors, ten are federal authorities, with the remaining four being two cantonal authorities and two research organisations. The FOEN, despite its role as the primary central coordinator for Swiss climate change adaptation, has a significantly lower proportion of cross-sectoral ties than the other federal offices. The reason for this discrepancy is that the FOEN plays an important coordinating role in the pilot project adaptation, which aims to foster adaptation at subnational levels. Thus, the FOEN also built a high number of cross-level ties to actors from within the same sector of environmental policy, consequently lowering the proportion of cross-sectoral ties. All the other federal agencies are particularly active in building cross-sectoral ties to other federal actors. Comparing the total number of ties shows that the FOEN is more successful in building both cross-level and cross-sectoral ties than any other actor.

The federal government is much better represented among the most important bridging actors than what would be expected if administrative level or governmental status did not matter regarding bridging roles. Thus, the data supports my first two hypotheses.

Lastly, I expected research organisations to be more likely to take on bridging roles than other non-governmental actors due to the importance of developing and disseminating knowledge during the early stage of adaptation policies characterised by countless uncertainties. I find strong support for this hypothesis, with the two only non-governmental actors identified as important bridging actors being research organisations.

### 15.8 Conclusions

My results show that federal governmental actors are most likely to take on bridging roles both amongst administrative levels and amongst policy sectors. This result departs from similar analyses of other multi-level governance issues such as environmental policy or land-use and water governance, which find that regional actors generally play more important coordinating roles than federal authorities (Angst et al., 2018; Hamilton et al., 2021; Henry et al., 2011; Ingold, 2014). While these differences may partially be attributed to different research designs, the difference in policy fields is certainly another important factor. Whereas environmental policy, land-use planning, or water governance are well established fields, climate change adaptation has only recently begun to develop into a full-fledged policy field of its own (Massey & Huitema 2016). The special status of climate change adaptation as an emerging policy field is further exemplified by the central role played by two research institutions. Accessing and distributing new information is well accepted as one of the key functions and benefits of central coordinators in policy

networks (Berardo & Scholz, 2010). However, it is rather uncommon for research institutions to occupy a central coordinator position themselves. Thus, my results demonstrate how the relative prioritization of different governance functions and the actors providing them may vary depending on how well-established a given field of policy is, lending credence to Massey and Huitema's (2013, 2016) call on policy researchers to pay more attention to how policy fields as a whole form and change to better understand policy change and the role different actors play therein.

The FOEN is by far the most important bridging actor in Swiss climate change adaptation. This is not surprising, as the FOEN was supposed to take on a coordinating role amongst sectors for the design and implementation of the Swiss adaptation strategy. Nevertheless, it is remarkable that the federal government plays such an important role even in the Swiss system, which focuses on delegating power and responsibility to the subnational levels. Comparable multi-level governance issues in Switzerland such as land-use or water governance are highly decentralized. Cantonal authorities take on the most important bridging roles with specific tasks commonly being delegated to municipalities (Angst et al., 2018; Ingold, 2014). In comparison, Swiss adaptation policy at the federal level has so far been focused on mainstreaming and cross-sectoral cooperation and many cantons and municipalities still lack formal adaptation policies or strategies (Braunschweiger & Pütz, 2021). Thus, the efforts at the federal level dominate the adaptation field so far. Many cantons have only recently appointed adaptation contact points, and many municipal adaptation initiatives have been fostered by the federal level rather than the cantonal level. The Swiss federal authorities have so far mostly built cross-sectoral ties, while cross-level ties are rarer. This result is in line with empirical studies on the implementation of adaptation, which find that many European nations struggle to translate national level adaptation policies and coordination efforts into concrete adaptation efforts at subnational levels (Bednar et al., 2019; Braunschweiger & Pütz, 2021; Runhaar et al., 2018). The high number of cross-level ties the FOEN established through the coordination of the pilot programme adaptation demonstrates the importance of these efforts to foster adaptation on the cantonal and municipal levels. However, if the federal government is to continue playing this key coordinating role in Swiss adaptation policy, it may require more funds dedicated to adaptation to finance measures such as the pilot programme and to reach a broader audience at the municipal level. On the other hand, if cantonal governmental actors are to systematically take on more important roles in Swiss adaptation governance as they do for comparable multi-level governance issues, a clearer legal mandate may be required to force even the stragglers to do so. The present lack of both dedicated funds for the current most important adaptation bridging actors to fulfil their roles more

effectively and of a legal mandate for other potentially important bridging actors to take over may be one of the most important reasons for the Swiss adaptation implementation gap.

My empirical analysis is limited to the case of Switzerland. Switzerland is a wealthy country well-known in political science for its focus on consensual politics as well as its effective and well-trusted government agencies (Kriesi & Trechsel, 2008; Sciarini et al., 2015). Thus, some of my results, especially those relating to the central role played by governmental actors, may not be perfectly applicable beyond the Swiss context. However, I expect federal government actors to play an important coordinating role during the emergence of adaptation as a new policy field in most countries with similarly well-established governmental institutions.

One possible disadvantage of my methodological approach was that I relied on the completeness of my initial sample to define the network boundaries. Additional policies and measures were only included if they either had a well-documented connection to the initial sample or were mentioned by my interview partners. Thus, it is possible that I missed some important bottom-up adaptation initiatives originating at the municipal or cantonal level that had no link to the national adaptation strategy or action plan. It is unlikely, that this caused me to miss any truly important initiatives as they should have been caught during the expert interviews. Nevertheless, my methodological approach centred on national adaptation policies and the policies and measures resulting therefrom, which may be a part of the reason why most of the bridging actors I identified were federal agencies and few municipal governmental actors are represented in my sample. Another flaw of my research design is that it cannot account for how actor constellations change over time. However, limiting the analysis to a relatively short period of time as I did, increases the likelihood that actor constellations have remained stable throughout the observed period. As my data collection process finished in 2018, the empirical analysis also did not take the updated version of the national action plan adaptation or the second round of the pilot programme adaptation into account.

Additionally, my methodological approach, especially the betweenness centrality and change in network modularity thresholds chosen to identify central coordinators and periphery connectors could benefit from further examination and empirical testing to ascertain how well suited they are to this purpose.

Lastly, my reasoning for researching bridging actors is based on the idea that reducing fragmentation and improving collaboration through bridging will lead to improved policy outcomes. However, as I have gathered no data on actual outcomes, I have not empirically tested this assumption. Future research

aiming to improve our understanding of how ties amongst actors influence policy outcomes should strive to address this research gap.

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## 15.10 Conflict of Interest

The author declares that he has no conflict of interest.

### 15.11 Annex

| Surname | Name | Institution | Country |
|---|---|---|---|
| Hojeksy | Helmut | Bundesministerium für Landwirtschaft, Regionen und Tourismus Österreich BMLRT | Austria |
| Jäger | Cornelia | Bundesministerium für Landwirtschaft, Regionen und Tourismus Österreich BMLRT | Austria |
| Bürgel | Jochen | Umweltbundesamt Österreich UBA AT | Austria |
| Lexer | Wolfgang | Umweltbundesamt Österreich UBA AT | Austria |
| Ebert | Sebastian | Umweltbundesamt Germany - Climate Impacts and Adaptation UBA KomPass | Germany |
| Lange | Andrej | Umweltbundesamt Germany - Climate Impacts and Adaptation UBA KomPass | Germany |
| Vetter | Andreas | Umweltbundesamt Germany - Climate Impacts and Adaptation UBA KomPass | Germany |
| Cetara | Luca | eurac Research Alpine Convention | Italy |
| Ballarin-Denti | Antonio | Fondazione Lombardia per l'Ambiente FLA | Italy |
| Pregnolato | Marco | Fondazione Lombardia per l'Ambiente FLA | Italy |
| Summer | Heike | Amt für Umwelt Liechtenstein AfU | Liechtenstein |
| Simonic | Barbara | Ministry of the Environment and Spatial Planning Slovenia MoP | Slovenia |
| Probst | Thomas | Bundesamt für Umwelt Schweiz BAFU | Switzerland |
| Braunschweiger | Dominik | Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL | Switzerland |
| Pütz | Marco | Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL | Switzerland |

Table 15-5: Attendees of the INTERREG workshop to identify the most important adaptation policies and measures in the Alpine Space

| Anpassung an den Klimawandel - Sektorale Massnahmen |
|---|
| Anpassung an den Klimawandel Berichterstattung der Kantone 2015 |

| |
|---|
| Anpassung an den Klimawandel in der Schweiz - Aktionsplan 2014–2019 2.Teil der Strategie des Bundesrates vom 9. April 2014. 2014 |
| Anpassung an den Klimawandel in der Schweiz - Ziele Herausforderungen und Handlungsfelder 1. Teil der Strategie des Bundesrats vom 12. März 2012 |
| CH2014 Impacts - Towards quantitative scenarios of climate change impacts in Switzerland |
| CO2 Gesetz |
| CO2 Verordnung |
| Controlling Bericht zur Strategie Anpassung an den Klimawandel und zum Bericht Umgang mit lokaler Wasserknappheit in der Schweiz |
| Evaluation Pilotprogramm Anpassung an den Klimawandel |
| Governance der Anpassung an den Klimawandel in Regionen - Schlussbericht |
| Impulse für eine klimaangepasste Schweiz - Erkenntnisse aus 31 Pilotprojekten zur Anpassung an den Klimawandel |
| Klimaanalyse der Stadt Zürich - Wissenschaftlicher Endbericht |
| Klimaanpassung Graubünden |
| Klimawandel GR Tätigkeitsbericht 2009 |
| Klimawandel Graubünden Arbeitspapier 1 - Anpassung |
| Klimawandel Graubünden Arbeitspapier 4 - Synthese |
| Kurzbeschreibung Klimaänderung und Hydrologie in der Schweiz (CCHydro) |
| Masterplan Umwelt 2017-2020 Zürich |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht ACCLAMÉ: Wiederherstellung der Biodiversität in alpinen Teichen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht ACCLIMATASION: Eine klimaangepasste Stadtentwicklung für Sitten |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Anpassung an den Klimawandel im Bereich der Biodiversität im Kanton Aargau |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht AquaFutura: Regionales Wassermanagement im Parc Ela |

| |
|---|
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Ausbildung der Einsatzkräfte |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Bodenfeuchtemonitoring Zentralschweiz |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Davos +1,7 °C konkret: Vom Klimawandel zum Klimahandeln |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Effekt von Hitzeperioden auf die Sterblichkeit und Adaptionsmassnahmen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Empfindlichkeit von Quell-Lebensräumen gegenüber Klimaveränderungen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Entwicklung der Proliferativen Nierenkrankheit bei freilebenden Forellen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Erhaltung der Wasserressourcen im Einzugsgebiet von Moorbiotopen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Expertenwissen für die Anpassungspraxis im Wallis nutzbar machen |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Indexbasierte Graslandversicherung |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Klimaadaptionsstrategie Grimselgebiet |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Klima-Toolbox Surselva: Ein Werkzeugkoffer für die Anpassung |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Lösungsansätze zur Sicherung von Flächen für Hochwasserkorridore |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Nationales Programm zur Überwachung der Asiatischen Tigermücke |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Notfall- und Massnahmenplan Wasserknappheit im Smaragd-Gebiet Oberaargau |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Nutzung von Fliessgewässern unter veränderten klimatischen Bedingungen |

| |
|---|
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Optimale Nutzung der Wasserressourcen durch die Landwirtschaft |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Regionale Anpassungsstrategie Klimawandel Sursee-Mittelland |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Risikobasierte Raumplanung: Eine Antwort auf den Klimawandel |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Risikokonzept für Eisschmelzprozesse in der Kryosphäre |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Strategien zur Geschiebebewirtschaftung im Zusammenhang mit dem Klimawandel |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Überwachungssystem für Kulturpflanzenschädlinge |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Umgang mit Wasserknappheit in der Thurgauer Landwirtschaft |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Urban Green & Climate Bern: Bäume für die klimaangepasste Stadtentwicklung |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Verbesserte Bodenfunktionen zum Ausgleich klimatischer Extreme |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Vorbereitung der Futterproduktion auf den Klimawandel |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Vorkommen, Ökologie und Kontrolle des Götterbaums in der Schweiz |
| Pilotprojekte zur Anpassung an den Klimawandel - Schlussbericht Wasserknappheitshinweiskarten im Einzugsgebiet des Vierwaldstättersees |
| Schlussbericht des Forschungsprojekts Anpassungsfähigkeit der Schweiz an den Klimawandel |
| Schlussbericht Evaluation der Strategie zur Anpassung an den Klimawandel Modul A - Interface |
| Schlussbericht Evaluation Pilotprogramm zur Anpassung an den Klimawandel Modul B - Interface |
| Schlussbericht Klimaanpassung Graubünden |
| Stand der Umsetzung bei der Anpassung an den Klimawandel Fortschrittsbericht 2015 |

| |
|---|
| Synthesebericht Klimabedingte Risiken und Chance Schweiz |
| Szenarien zur Klimaänderung in der Schweiz 2011 |

**Table 15-6: Full list of analysed documents**

An interactive visualization of the data on Swiss climate change adaptation governance that served as the basis for this social network analysis can be accessed at: https://www.wsl.ch/gov-vis-cca/#switzerland

# 16 What Drives Local Climate Change Adaptation? A Qualitative Comparative Analysis

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## 16.1 Abstract

Climate change impacts vary wildly across different geographical contexts and their effects are primarily felt on the local level, generating demand for local solutions. The local level plays a key role in the adaptation to climate change. Nevertheless, in most European countries adaptation has yet to be integrated comprehensively into local policy agendas. To further our understanding of this slow pace of local adaptation progress, we study 21 Swiss Alpine municipalities exposed to a variety of natural hazards and issues exacerbated by local climate change impacts. Building on established research on local natural hazard management and climate change adaptation, we expect four factors to play decisive roles, either on their own or in combination with each other: Past extreme events, risk exposure, perceived climate risk and existing adaptation policies at superordinate levels. We test these expectations using qualitative comparative analysis (QCA). We find that significant past extreme events and high perceived climate risk come close to being necessary conditions for local adaptation measures. High perceived climate risk on its own is also a sufficient condition for local adaptation measures to be taken while its absence is sufficient for no local adaptation measures to be taken. Thus, the importance of climate risk perception exceeds our expectation as it has clearly been revealed to be the most important factor. Future research should focus on disentangling different levels of public risk perception further and investigate the role different levels of perception or acceptance among different actor groups play in climate policy decisions.

### 16.2 Keywords

Climate Change Adaptation; Governance; Environmental Policy; QCA; Local Climate Change Adaptation

Length of the manuscript (excluding reference list, tables, figures, captions, author details, titles, abstract and acknowledgement): 6844 words

Number of tables: 7

Number of illustrations: 0

### 16.3 Conflict of Interest

The authors declare that they have no conflict of interest.

## 16.4 Introduction

The variety of local impacts of climate change combined with our improving understanding of the limits of monotonous, large-scale, top-down adaptation approaches has led to a broad recognition that the local level has a significant role to play in adaptation to climate change (Aguiar et al., 2018; Amundsen et al., 2018; Fazey et al., 2018; Fuhr et al., 2018; Walker et al., 2015). In most democratic countries, the local level has at least partial jurisdiction over many governmental functions relevant to adaptation. Some prominent examples include the protection of infrastructure, emergency planning, and land use regulations (Vogel & Henstra, 2015). Moreover, the impacts of climate change are mostly felt at the local level (Hunt & Watkiss, 2011), generating demand for local solutions. There is also a popular argument that local stakeholders need to be included in decision-making processes because they are in the best position to solve problems related to the degradation of local resources (Ostrom, 2000) and garner local support for cooperative solutions (Ostrom, 2010). Additionally, local stakeholders are able to tailor their approaches to local community needs and specific local vulnerabilities (Corfee-Morlot et al., 2011; Smit & Wandel, 2006). Thus, both the scientific community and European Commission recognize the importance of the local level for adaptation to climate change (Fünfgeld, 2015; Nordgren et al., 2016; Robert & Schleyer-Lindenmann, 2021; Twecan et al., 2022). This is also reflected in the European Adaptation Strategy, which calls on EU member states and municipalities to jointly design and implement adaptation policies (European Commission, 2021).

However, despite the strategic importance of the local level and the many successful implementations of adaptation measures across the globe, adaptation has yet to be integrated comprehensively into local policy agendas in many countries (Dupuis & Knoepfel, 2013; Fünfgeld, 2015). Attempts to decipher the reasons for this slow progress have commonly focused on identifying barriers to local adaptation (Biesbroek et al., 2015). Specifically, local authorities often have difficulties in dealing with long-term problems (Biesbroek et al., 2010). Local adaptation is also embedded in larger multi-level arrangements and thus highly dependent on upper and lower levels of climate decisions as well as actions taken by other parallel constituencies (Omukuti, 2020; Yu, 2016). Additionally, the design of adaptation policies is complicated by the temporal and spatial mismatch between the source of the problem and its effects (Driessen et al., 2012; Ingold et al., 2019). Moreover, even though public awareness of manmade climate change and its impacts is rising, many still perceive climate change as a distant issue and do not acknowledge any urgent need for adaptation measures (Perrow, 2010). This is compounded by the fact that the costs of adaptation measures are immediate, while pay-outs are often subtle and will take place

years in the future, leading many local authorities to instead prioritize more immediate issues (Vogel & Henstra, 2015).

However, the limited focus on barriers to adaptation is conceptually problematic and struggles to explain adaptation decision-making (Biesbroek et al., 2015). Researching the adaptation implementation deficit by exclusively studying barriers to adaptation assumes that political decision-making processes should be producing adaptive policies – if only the aforementioned barriers did not exist (Biesbroek et al., 2015). Further, compiling influential factors and categorizing them as barriers does not actually improve our understanding of the decision-making processes that led to the adaptation implementation deficit. Consequentially, "ten years of barrier thinking and analysis have yielded very limited advice about how to intervene in practice to secure better outcomes" (Biesbroek et al., 2015). Thus, our goal in this paper is to move beyond the study of barriers by identifying what causes municipalities to engage in adaptation. Specifically, we aim to answer the following research question:

What combination(s) of factors lead municipalities to adopt climate change adaptation measures?

To answer this question, we compare how different Alpine municipalities in Switzerland approach adaptation to climate change. We analyse municipalities exposed to various natural hazards—such as floods, avalanches, rock fall and landslides—which threaten to grow more intense and frequent due to the impacts of climate change. Next, through a qualitative comparative analysis (QCA), we identify the factors that are key to explaining whether municipalities engage in climate change adaptation or not.

## 16.5 Local Climate Change Adaptation

The majority of climate change adaptation efforts must take place at the local scale ((Fünfgeld, 2015; Nordgren et al., 2016). Nevertheless, huge potential to further integrate mitigation and adaptation initiatives at the local scale remains (Fünfgeld, 2015; Hurlimann et al., 2021). As many studies have shown, local climate change adaptation can take a variety of forms and is highly dependent on geographical, topographical, and socio-cultural context (Bauer & Steurer, 2015; Betsill & Bulkeley, 2006; Hegger et al., 2014; Sarker et al., 2020). Specifically, some authors have stressed the dominant role of water-related actions (e.g., concrete measures such as dams or spatial planning measures) and studies when it comes to climate change adaptation. One major reason for this focus is that floods or droughts were addressed by local authorities in many countries even before climate change impacts entered the political agenda

(Bauer & Steurer, 2015; Křištofová et al., 2022). However, local climate change adaptation studies also prominently focus on other issues such as food production, land use, or forestry (Ahmed et al., 2021; Ingold & Fischer, 2014; Keenan, 2015).

From a policy perspective, local climate change adaptation might be more homogenous across and within countries, different geographical areas, political styles, and institutions (Baker et al., 2012; Nordgren et al., 2016): it includes goals and measures to reduce a community's vulnerability or exposure to any type of climate change effect (Baker et al., 2012; Khailani & Perera, 2013; Robert & Schleyer-Lindenmann, 2021). Therefore, local climate change adaptation in this regard is a strategic declaration to adapt to climate change and its consequences within the local constituency, which is typically a municipality or city (Křištofová et al., 2022).

### 16.6 Conditions for the Adoption of Climate Change Adaptation Measures by Municipalities

As outlined above, we are interested in local climate change adaptation from a policy perspective. We examine potential drivers that may explain the stronger or weaker adaptation policies and strategies adopted by municipalities. Here, we review the literature and outline the expectations about such potential factors.

One important effect of climate change, mainly in mountain regions (NCCS, 2018), is the increased frequency and intensity of extreme events such as floods, droughts, or heavy rainfalls (IPCC, 2022). Extreme events can be an important driver for policies to be designed, introduced, or changed (Birkland, 1998; Kingdon, 1984). They can have dramatic agenda-setting effects, generating increased attention for a public problem. Thus, they may increase public support for potential solutions and have accordingly been identified as important stimuli for adaptation measures (Berrang-Ford et al., 2011). From this literature, we deduce our first expectation as follows:

> Expectation 1: The recent occurrence of an extreme event contributes to the adoption of climate change adaptation measures by municipalities.

Meanwhile, recent literature increasingly emphasizes that the (political) context, as well as the properties of an event, significantly affect the extent to which an event triggers and shapes policies (Birkland & Warnement, 2014). Further, direct experience with extreme events also increases individual support for mitigation measures (Tanner & Árvai, 2018). However, these effects are often temporary, as in the absence of new events, other policy issues resurface and supplant the event-related issues (Atreya et al.,

2015). Combining these two insights (specific properties of the events and temporal aspects), long-term and steady exposure (in contrast to the recent occurrence of events) to threats may also be an important driver for local climate change adaptation measures. Thus, repeated exposure increases attention to a problem even if some time has passed since the last extreme event (Giordono et al., 2020).

> Expectation 2: Persistent risk exposure contributes to the adoption of climate change adaptation measures by municipalities.

Additionally, recent research indicates that risk perception may play an equally or even more important role than risk exposure or the experience of extreme events (Glaus et al., 2020; Herzog & Ingold, 2019). For example, Petrolia et al. (2013) showed that household level decision-making on flood insurance purchases depends on individual risk aversion and perception. Atreya et al. (2015), who likewise studied flood insurance purchases, concluded that while exposure does play an important role, so does risk perception. Meanwhile, Twecan et al. (2022) found that risk perception is directly related to climate change adaptation measures. Their study of smallholder farmers in Uganda showed that risk perception is not only dependent on experience with extreme events and other climate risks but also socio-cultural factors, such as the level of education. They concluded that understanding farmers' climate risk perceptions is critical to designing and implementing effective farm-level context-specific climate change adaptation policies by concerned government authorities.

> Expectation 3: Increased climate change risk perception by the population contributes to the adoption of climate change adaptation measures by municipalities.

As climate change adaptation is a multi-level challenge (Bauer & Steurer, 2014), another important driver for local adaptation action may be the adaptation policies and measures taken at superordinate administrative levels. The local level is commonly expected to take on the design and implementation of concrete adaptation measures (Keskitalo, 2010). Nevertheless, local adaptation is embedded in multi-level arrangements with regional and national actors who gather and disseminate relevant knowledge, provide funding, or define legal guidelines (Galarraga et al., 2011). Moreover, local adaptation is heavily influenced by regional and national actors and institutions. Governance structures at the national or regional level can be important barriers or success factors for the implementation of adaptation measures at the local level (Amundsen et al., 2010; Juhola, 2016). The decentralized nature of multi-level governance systems allows policy initiatives to arise at different levels and best practices to diffuse across scales (Di Gregorio et al., 2019; Underdal, 2010). Frequent interactions are an important prerequisite for

policy diffusion (Braun & Gilardi, 2006; Kammerer & Namhata, 2018). Thus, vertical policy diffusion may be especially likely, as federal governance structures typically foster frequent interactions between subordinate and superordinate levels. Shipan and Volden (2006) showed that demonstrating the viability of local policy initiatives facilitates their adoption at the state level. Braunschweiger and Pütz (2021) discovered similar mechanisms in the diffusion of national or state-level policies to the municipal level: policy innovators at the local level commonly cite the existence of comparable policies at superordinate levels as an important success factor as they provide technical guidance, good-practice examples, and political legitimization to local initiatives. Thus, whether adaptation policy exists at a superordinate level can also be assumed to be an important driver for local climate change adaptation action.

> Expectation 4: The existence of a climate change adaptation policy at the superordinate level contributes to the adoption of climate change adaptation measures by municipalities.

Three of our four expectations pertain to risk – immediate risk exposure, persistent risk exposure and risk perception. Recent research suggests that that the decisive question may be, how risk perception and objective risk exposure relate to each other (Glaus et al., 2020; Herzog & Ingold, 2019). As such, we are particularly interested in the relative impact as well as possible interaction effects between these three conditions. Is it immediate risk exposure or persistent risk exposure that matters most? Or is a combination of both necessary for adaptation measures to be taken? Or is risk perception key and risk exposure mostly matters insofar as it influences risk perception? Additionally, Braunschweiger and Pütz (2021) suggest that existing climate policies at superordinate levels provide important guidance and political legitimization to adaptation efforts at lower levels. As such, it is possible that the existence of such strategies in combination with the presence of other factors related to risk and risk perception is necessary for municipalities to adopt climate change adaptation measures.

Thus, we do not aim to test our four expectations independently (Perez et al., 2015). We are convinced that it is the combination of factors, that leads to the adoption of climate change adaptation measures at the municipal level. The adequate model for investigating whether combinations of conditions affect an outcome, is QCA (Timberlake & Ragin, 1989).

QCA conceptualizes causal factors as combinations of conditions. Multiple different combinations of factors, or pathways, may lead to the same outcome, and the occurrence of the outcome and non-outcome may require separate pathways. These three concepts of conjunctural causation, equifinality,

and causal asymmetry together are often described as causal complexity, which is one of the main elements of QCA (Mello, 2022; Rihoux & Ragin, 2008; Schneider & Wagemann, 2012).

## 16.7 Cases and Methods

### 16.7.1 Case Selection and Data Collection

Through our review of the existing literature, we formulated four expectations regarding the drivers of the adoption of local climate change adaptation measures. Three of these expectations concern immediate and persistent risk posed by extreme events and the impacts of climate change on the frequency and intensity of natural hazards as well as the perception of said risk. As such, we are particularly interested in municipalities exposed to different types of extreme events and natural hazards, such as flooding, mudflows, avalanches, and rockslides. As Alpine regions are particularly vulnerable to such risks (BAFU, 2012; Brönnimann et al., 2014; Köllner et al., 2017), we have confined our case selection to Swiss Alpine municipalities exposed to different varieties of natural hazards.

We first selected interesting municipalities based on desktop research on local adaptation projects in the Alpine regions of Switzerland as well as a preliminary analysis of cantonal natural hazard risk maps. We further refined this selection through five expert interviews with natural hazard management executives at federal and cantonal levels as well as experts on Swiss natural hazard management from among the scientific community to ensure that our cases included sufficient variance in terms of our explanatory variable. Next, we collected in-depth data on risk exposure regarding each case through a detailed analysis of the natural hazard risk maps, hazard zone maps, and the natural hazard database StorMe. We consulted any existing cantonal adaptation policies as well as survey data collected by the Swiss Broadcasting Corporation (SRG SSR) and Link Institute (2017) on the perceived risk posed by climate change to respondents. As this survey data does not include sufficiently large samples from the smaller Alpine cantons, we limited our case selection to the three larger cantons of Bern, Grisons, and Valais. Finally, we consulted data collected by the Federal Statistical Office (FSO) on local election outcomes in the 2019 election of the national council for one of the additional conditions to be employed in our robustness test.

Through this process, we settled on 29 municipalities, 8 of which had no interest in our interview request, leaving us with a final sample of 21 municipalities, as depicted in Table 1.

| Municipality | Canton | Abbreviation |
|---|---|---|
| Leuk | VS | Leu |
| Randa | VS | Ran |
| Saviese | VS | Sav |
| St. Niklaus | VS | Nik |
| Täsch | VS | Täs |
| Zermatt | VS | Zer |
| Diemtigen | BE | Die |
| Grindelwald | BE | Gri |
| Gsteig | BE | Gst |
| Guttannen | BE | Gut |
| Innertkirchen | BE | Inn |
| Iseltwald | BE | Ise |
| Kandersteg | BE | Kan |
| Lauterbrunnen | BE | Lau |
| Schattenhalb | BE | Sat |
| Albula | GR | Alb |
| Bregaglia | GR | Bre |
| Flims | GR | Fli |
| Ilanz/Glion | GR | Ila |
| Küblis | GR | Küb |
| Pontresina | GR | Pon |

Table 16-1: Municipalities in the Sample

### 16.7.2 Method

We identified four drivers that we expect to influence whether municipalities engage in climate change adaptation action. We are interested in the roles these drivers play, not just on their own but in any possible combination. Consequently, we tested our expectations regarding the influence of these factors using a fuzzy-set QCA. QCA aims to identify necessary and sufficient combinations of conditions for specific outcomes to occur using in-depth observations of a medium number of cases. (Rihoux & Ragin, 2008; Timberlake & Ragin, 1989). It is a set-theoretic method that assigns each case with a set membership score for each condition as well as the outcome. It then employs logical minimization following the principles of Boolean algebra to eliminate irrelevant conditions (Rankin, 2008; C. Q. Schneider &

Wagemann, 2012). This method suits our purposes for two reasons: first, its logic of equifinality and conjunctural causation is well-suited to our expectation that the relationship between objective and perceived risk exposure may be a deciding factor for the occurrence of local climate change adaptation; second, QCA is well suited for the analysis of a medium number of cases (Mello, 2022). QCA postulates, that outcome and non-outcome may require different pathways. Thus, we performed separate analyses to identify necessary and sufficient combinations of conditions for both the outcome and non-outcome.

Fuzzy-set QCA, as compared to crisp-set QCA, can assign set membership scores that are more nuanced than 0 and 1. Fuzzy sets have the advantage of losing less information in the calibration of all conditions that are not naturally dichotomous, as it allows for more sophisticated nuances to be analysed (Mello, 2022).

QCA employs several measures of fit to assess the reliability of its results. The most important of these measures are tests of consistency, coverage, relevance of necessity (RoN), and proportional reduction in inconsistency (PRI) (Mello, 2022). Specifically, the consistency of necessary conditions measures the degree to which "the outcome can be considered a subset of the condition" (Schneider & Wagemann, 2012 p.143) while the consistency of sufficient conditions measures "the degree to which the empirical information deviates from a perfect subset relation" (Schneider & Wagemann, 2012 p.129). Coverage measures the proportion of cases where we observe the outcome that can be explained by the presence of a condition or combination of conditions (Rihoux & Ragin, 2004) and thus, how important said condition is. RoN measures whether a necessary condition or combination of conditions is trivial in so far as the condition is present in almost all cases (C. Q. Schneider & Wagemann, 2012). Finally, when analysing fuzzy-set data, certain conditions or combinations of conditions may be a subset of both the outcome and non-outcome and may thus be identified as sufficient conditions for both. The PRI helps identify such logical contradictions (C. Q. Schneider & Wagemann, 2012). Low PRI values indicate that the condition or combination of conditions may not actually be sufficient for the outcome, despite consistency and coverage scores suggesting otherwise.

The results of QCA can also vary significantly based on condition calibration, case samples, consistency thresholds and other decisions made by the researchers. Thus, we perform robustness tests (Cooper & Glaesser, 2015; Ide et al., 2020; C. Q. Schneider & Wagemann, 2012) to check how well our results hold up when our model is subjected to different alterations (see annex).

### 16.7.3 Outcome: Measures Addressing Local Climate Change Adaptation

A key challenge for many comparative studies on climate change adaptation policy is the definition and operationalization of the dependent variable (Dupuis & Biesbroek, 2013). While many different definitions of climate change adaptation exist, most suggest that adaptation involves reducing vulnerability to impacts of climate change and increasing adaptive capacity (Smit & Pilifosova, 2001; Smit & Wandel, 2006; Vogel & Henstra, 2015). However, this definition is still quite broad and may incorporate many different activities. Our interest lies in whether municipalities adopt climate change adaptation measures or not, and if yes, the extent to which they do so. Thus, we conceptualize the Outcome (*OUT*) of local climate change adaptation as any local measure with the specific goal to reduce vulnerability to climate change impacts and/or to increase the municipality's ability to moderate and cope with negative consequences of climate change. *OUT* is operationalized based on our interview results. A value of 0 indicates that the municipality has not adopted any climate change adaptation measures at all. A value of 0.33 indicates that the municipality has not explicitly dealt with climate change adaptation, but local natural hazard management is well prepared to deal with any local climate change impacts that may arise during the coming years. A value of 0.66 indicates that the municipality has dealt explicitly with local climate change impacts and climate change adaptation in some form. A value of 1 indicates that the municipality has additionally adopted or participated in concrete adaptation measures.

### 16.7.4 Conditions: Their Operationalization and Calibrations

We operationalize the four drivers outlined in our expectations with four "conditions", as they are called in QCA. As for the outcome, we employ four-value fuzzy-set calibrations for the four conditions.

To operationalize our first two conditions, recent occurrence of extreme events (*EVENT*) and persistent risk exposure (*DANGER*), we consider floods, landslides, rockslides, mud and snow avalanches, and mudflow.

Data for the operationalization of our first condition, the recent occurrence of extreme events (*EVENT*), were collected from the StorMe database and through our interviews. The condition was calibrated according to event magnitude, how long it has been since the events took place, the monetary damages, and whether anybody was significantly hurt or killed. A value of 0 indicates that there were no large events impacting infrastructure or settled areas during the last 10 to 15 years. A value of 0.33 indicates that one or multiple events took place during the last 10 to 15 years but did not cause any damage exceeding the low four-digit range (in Swiss Francs). A value of 0.66 indicates that one or multiple events took place during the last ten to fifteen years and caused damage in the high four-digit to low five-digit range. Finally,

a value of 1 indicates that recent events caused damages exceeding the low five-digit range, caused harm to persons, or took place within the last two years or a combination thereof.

The second condition, persistent risk exposure (*DANGER*), is operationalized based on cantonal natural hazard risk maps, which serve as an important basis for land use planning and regulation. They categorize settlement areas into five denominations: high risk, medium risk, low risk, negligible risk, and no risk. To calibrate risk exposure, we calculate the share of each of these categories in the total settlement area. Unfortunately, synoptic danger maps were available only for the canton of Bern. Thus, we had to evaluate hazard maps regarding individual hazards for cases in Grisons or Valais, which we complemented by also evaluating danger zone maps. Danger zone maps offer a synoptic assessment with direct legal relevance for land use; however, they are less nuanced than risk maps. As these differences between cantons impede cross-cantonal comparisons, cases are calibrated based on cantonal means and standard deviations. Municipalities with a below average percentage of settled areas in high-risk zones are assigned a value of 0.33 or 0 based on whether they lie within one standard deviation below the average or not and vice versa for values above average.

The third condition, increased risk perception (*PERC*), is operationalized based on three different measurements: First, the SRG SSR and the Link Institute conducted a representative survey on climate change in 2017, which included the question “How would you estimate the risk posed by climate change to you personally?” Wieser (2019) calibrated this data for a QCA of Swiss cantonal adaptation policies. We adopt her calibration of the data with values closer to 1, indicating higher perceived risk. Unfortunately, this data is only available at the cantonal level. Thus, we supplemented it by also asking interviewees how they judged the level of concern among the general population of their municipalities in terms of natural hazards as well as local climate change impacts and the potential cascading effects of these impacts on natural hazards. Based on their assessment, we coded public concern about natural hazards and local climate change impacts: a value of 0 means they are not at all concerned, a value of 0.33 means they are a little concerned, a value of 0.66 means they are somewhat concerned, and a value of 1 means they are very concerned. These three variables were then added together, and the new combined variable was calibrated based on deviation from the mean.

The fourth condition concerns the existence of climate change adaptation policies at the superordinate cantonal level (*STRAT*). It is assessed based on an inventory of cantonal climate policies by the Swiss National Centre for Climate Services (NCCS). The canton of Bern has yet to formulate an adaptation strategy but has published a preparatory report on climate change adaptation that contains important

policy directives on adaptation. Thus, we assign it a value of 0.67. Meanwhile, the canton of Grisons has formulated a climate strategy that presents climate mitigation and adaptation as equivalent and synergistic components. We consequently assigned it a value of 1. Finally, the canton of Valais has yet to publish any official strategy or guidelines on climate change adaptation, and we thus assigned it a value of 0.

For our robustness tests, we also include two additional control variables to emphasize potential drivers due to politics (Birkland & Warnement, 2014) and in accordance with similar QCA studies (Kammermann, 2018; Popp et al., 2021; Wieser, 2019), to also highlight politics and financial aspects of climate change and environmental policymaking.

In this context, one popular indicator of the political viability of different issues is the political composition of executive authorities. Regarding the issue of climate change adaptation, we expect left-wing environmental parties that have been politically invested in climate politics for decades to look more favourable on adaptation measures than other political parties (*LEFT*) (Neumayer, 2004; Pemberton, 1975; Stadelmann-Steffen & Dermont, 2018). While municipal executives in smaller Swiss municipalities commonly do not belong to any official political parties, following the same line of argument, we expect the supporters, sympathizers, and voters of left-wing environmental parties to be more supportive of climate change adaptation than the general populace (Neumayer, 2004). Therefore, we will include a control factor in our model based on the relative share of votes cast in favour of such parties during the last election of the national council. We draw our data on local election outcomes from the FSO and add up the collective share of the vote of left wing and environmental parties (*LEFT*): the Social Democratic Party of Switzerland (SP), the Green Party of Switzerland (GPS), the Green Liberal Party of Switzerland (GLP), the Swiss Party of Labour (PdA) and Solidarity (Sol).

Finally, we argue that local awareness of different adaptation policies as well as whether they are deemed viable depends on the financial and personnel resources of the responsible local governmental agencies. As Nordgren et al. (2016) showed the importance of resources related and attributed to local climate change adaptation. The impacts of climate change take many different forms and cross the boundaries between traditional policy sectors. As such, most adaptation policies are cross-sectoral. However, as we are specifically interested in the intersection of adaptation to climate change and natural hazard management, local natural hazard management agencies are the most relevant departments. Therefore, our second control condition is based on the resources and the degree of organization of local natural hazard management (*RES*). This condition is assessed based on our interview results.

Throughout the interviews, it became evident that personnel and financial resources were often difficult to quantify, as many important tasks were fulfilled by volunteers. Additionally, people responsible for natural hazard management at the local level often take on other responsibilities as well and were frequently unable to differentiate exactly how much time they spent on natural hazard management as opposed to other tasks. Thus, our calibration process considered several qualitative factors as gauged by the answers to the following questions: Has responsibility for natural hazard management been formally assigned to anybody? Does the municipality take a holistic approach towards natural hazard management, or are responsibilities scattered and partially unclear? Does the municipality employ anybody whose duties include some form of natural hazard management, or does it rely completely on volunteers? How well prepared is the municipality to take immediate measures in the case of an extreme event?

In addition to these qualitative assessments, we also consider the personnel and financial resources invested in the construction and maintenance of natural hazard measures as estimated by the local experts. A value of 0 indicates that the municipality in question lacks clearly defined responsibilities, invests comparatively little resources in natural hazard management, and lacks concrete plans on how to react to extreme events, while a value of 0.33 indicates that only one of these three problems persists. A value of 0.66 indicates that responsibilities are clearly defined, natural hazard management is well staffed and funded, and clear plans on how to react to extreme events are in place. Finally, a value of 1 indicates that the municipality additionally takes a particularly proactive approach to natural hazard management or invests considerably more funding in natural hazard management than comparable municipalities from our sample.

Table 2 depicts all six conditions as well as the abbreviations we employ to refer to them throughout this paper.

| Conditions | Abbreviations | Included in primary analysis |
|---|---|---|
| Recent extreme events | *EVENT* | ✓ |
| Natural hazard risk exposure | *DANGER* | ✓ |
| Perception of climate change | *PERC* | ✓ |
| Cantonal adaptation strategies | *STRAT* | ✓ |
| Voting share of environmental and left-wing parties | *LEFT* | × |
| Resources of local natural hazard management | *RES* | × |

Table 16-2: Conditions for the Qualitative Comparative Analysis on What Drives Climate Change Adaptation

Next, Table 3 shows the calibrations for all conditions and the outcome for all 21 municipalities:

| Gemeinde | Event | Danger | Perc | Strat | Left | Res | Outcome |
|---|---|---|---|---|---|---|---|
| **Leuk** | 1 | 0.66 | 0.66 | 0 | 0.33 | 1 | 0.66 |
| **Randa** | 0.66 | 0.33 | 0.66 | 0 | 0.33 | 1 | 0.66 |
| **Saviese** | 0.33 | 0.33 | 0.33 | 0 | 1 | 0.66 | 0.33 |
| **St. Niklaus** | 1 | 0.66 | 1 | 0 | 0 | 1 | 0.66 |
| **Täsch** | 0.33 | 0.66 | 0.66 | 0 | 0 | 0.66 | 0.66 |
| **Zermatt** | 1 | 0.66 | 1 | 0 | 0 | 1 | 1 |
| **Diemtigen** | 0.33 | 0.00 | 0.33 | 0.66 | 0 | 0.66 | 1 |
| **Grindelwald** | 0.66 | 0.00 | 0.33 | 0.66 | 0.33 | 1 | 0.33 |
| **Gsteig** | 0.33 | 0.00 | 0 | 0.66 | 0 | 0.66 | 0.33 |
| **Guttannen** | 1 | 0.66 | 1 | 0.66 | 0.66 | 0.66 | 1 |
| **Innertkirchen** | 0.66 | 1.00 | 0 | 0.66 | 0.33 | 1 | 0.33 |
| **Iseltwald** | 0.33 | 0.66 | 0 | 0.66 | 0.33 | 0.66 | 0.33 |
| **Kandersteg** | 1 | 0.33 | 0.33 | 0.66 | 1 | 1 | 0.33 |
| **Lauterbrunnen** | 0.66 | 0.66 | 0.33 | 0.66 | 1 | 0.66 | 0.66 |
| **Schattenhalb** | 0.33 | 0.00 | 0 | 0.66 | 0.33 | 0 | 0 |
| **Albula** | 1 | 1.00 | 1 | 1 | 0.66 | 1 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bregaglia** | 1 | 0.00 | 0.33 | 1 | 0.66 | 1 | 0.66 |
| **Flims** | 0.66 | 0.00 | 0.66 | 1 | 1 | 1 | 1 |
| **Ilanz/Glion** | 0.33 | 1.00 | 0.66 | 1 | 0.66 | 0.33 | 0.66 |
| **Küblis** | 0.66 | 1.00 | 0 | 1 | 0.66 | 0.33 | 0.33 |
| **Pontresina** | 0.33 | 0.00 | 0.33 | 1 | 0.66 | 0.66 | 0.33 |

Table 16-3: Case Values for All Conditions and The Outcome

## 16.8 Results

| | Adaptation (*OUT*) | | | ~Adaptation | | |
|---|---|---|---|---|---|---|
| | Consistency | Coverage | Relevance | Consistency | Coverage | Relevance |
| *EVENT* | 0.864* | 0.78 | 0.709 | 0.766 | 0.486 | 0.511 |
| *DANGER* | 0.622 | 0.792 | 0.849 | 0.536 | 0.48 | 0.692 |
| *PERC* | 0.812* | 0.968 | 0.97 | 0.419 | 0.351 | 0.614 |
| *STRAT* | 0.621 | 0.637 | 0.672 | 0.732 | 0.528 | 0.612 |
| *~EVENT* | 0.431 | 0.723 | 0.871 | 0.653 | 0.771 | 0.89 |
| *~DANGER* | 0.592 | 0.645 | 0.707 | 0.768 | 0.588 | 0.675 |
| *~PERC* | 0.456 | 0.527 | 0.672 | 0.962** | 0.782 | 0.817 |
| *~STRAT* | 0.539 | 0.741 | 0.838 | 0.496 | 0.479 | 0.72 |

Table 16-4: Analysis of Necessity

**Note: Conditions that meet the 0.9 consistency threshold for necessity are marked with two stars (**), while conditions that meet the 0.8 consistency threshold for necessity are marked with one star (*).**

We first checked for any necessary conditions for either the outcome (*OUT*) or the non-outcome. Necessary conditions are always present when the outcome is also present. Table 4 shows the consistency, coverage, and relevance of necessity for all conditions as well as the negation of each condition. Our analysis of necessity yielded no result above the 0.9 consistency threshold for the outcome

and one result above said threshold for the non-outcome. The conditions past extreme events (*EVENT*) and perception (*PERC*), narrowly fall short of the 0.9 consistency threshold but show relatively high coverage and relevance of necessity. This indicates that, while not consistently necessary for the outcome to occur, past extreme events (*EVENT*) and perception (*PERC*) are close to being non-trivial necessary conditions. We also found that the absence of perception (~*PERC*) is both a highly consistent and non-trivial necessary condition for no adaptation efforts to occur. However, perception (*PERC*) as a necessary condition for the outcome does not hold up well to our robustness tests (see annex). Past extreme events (*EVENT*) as a necessary condition for the outcome and the absence of perception (~*PERC*) as a necessary condition for no adaptation efforts are both highly robust results.

| EVENT | DANGER | PERC | STRAT | OUT | N | Consistency | PRI | Cases |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 | 3 | 1 | 1 | **Nik, Zer, Leu** |
| 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | **Gut, Lau, Alb** |
| 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | **Die** |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | **Täs** |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **Ila** |
| 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | **Ran** |
| 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | **Fli** |
| 0 | 1 | 0 | 1 | 0 | 1 | 0.82914573 | 0 | Ise |
| 0 | 0 | 0 | 0 | 0 | 1 | 0.79758308 | 0.33 | Sav |
| 1 | 0 | 0 | 1 | 0 | 3 | 0.7662037 | 0.49751244 | Gri, Kan, ***Bre*** |
| 1 | 1 | 0 | 1 | 0 | 2 | 0.7443609 | 0 | Inn, Küb |
| 0 | 0 | 0 | 1 | 0 | 3 | 0.63114754 | 0.32835821 | Sat, Gst, Pon |

Table 16-5: Truth Table for the Outcome of "Adaptation"

*Note: Cases in bold show the outcome, while those in italics are logical contradictions. Rows marked in grey were included in the minimization process.*

| EVENT | DANGER | PERC | STRAT | OUT | N | Consistency | PRI | Cases |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 1 | 1 | 2 | 1 | 1 | **Inn, Küb** |
| 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | **Ise** |
| 0 | 0 | 0 | 0 | 1 | 1 | 0.900302115 | 0.67 | **Sav** |
| 0 | 0 | 0 | 1 | 1 | 3 | 0.819672131 | 0.671641791 | **Sat, Gst, Pon** |
| 1 | 0 | 0 | 1 | 1 | 3 | 0.768518519 | 0.502487562 | **Gri, Kan, *Bre*** |
| 0 | 1 | 1 | 0 | 0 | 1 | 0.795180723 | 0 | Täs |
| 1 | 0 | 1 | 0 | 0 | 1 | 0.664987406 | 0 | Ran |
| 0 | 1 | 1 | 1 | 0 | 1 | 0.66 | 0 | Ila |
| 1 | 1 | 1 | 0 | 0 | 3 | 0.578947368 | 0 | Nik, Zer, Leu |
| 1 | 0 | 1 | 1 | 0 | 1 | 0.553691275 | 0 | Fli |
| 0 | 0 | 1 | 1 | 0 | 1 | 0.497487437 | 0 | Die |
| 1 | 1 | 1 | 1 | 0 | 3 | 0.33 | 0 | Gut, Lau, Alb |

**Table 16-6: Truth Table for the Non-outcome of "No Adaptation"**

*Note: Cases in bold show the outcome, while those in italics are logical contradictions. Rows marked in grey were included in the minimization process.*

Next, we aimed to identify sufficient combinations of conditions. Table 5 shows the truth table for the outcome excluding logical remainders. We aimed to minimize the number of logical contradictions. Thus, we set the consistency threshold for rows to be included in the minimization process at 0.9. This threshold surpasses the established minimum level of 0.75 (Ragin, 2006) and produces only one logical contradiction: The municipality Bregaglia shows the outcome but shares the exact same combination of conditions with the municipalities Kandersteg and Grindelwald, which do not (see Table 5). This row was thus excluded from the minimization process. We also set a PRI threshold of 0.5 to identify cases of simultaneous subset relations (C. Q. Schneider & Wagemann, 2012).

For the analysis of sufficiency regarding the non-outcome, we set the consistency threshold at 0.75 to minimize the number of logical contradictions. In combination with a PRI threshold of 0.5, the case of Bregaglia remains the sole logical contradiction (see Table 6). Table 6 shows the truth table for the non-outcome.

These truth tables are then used to derive less complex possible solution terms through minimization. Which type of solution should be preferred has been the subject of some debate. Baumgartner and Thiem (2017) advocate that only parsimonious solutions should be considered while Duşa (2019) argues that the intermediate solution should be preferred as it is the most able to accommodate both sufficiency and parsimony. We opt to use the parsimonious solution based on the argument that it is the most robust (Baumgartner & Thiem, 2017).

Table 7 displays the parsimonious solution terms for both the outcome and the non-outcome in the notation established by Ragin and Fiss (Fiss, 2011; Ragin & Fiss, 2008). Equifinal solution paths to the outcome and non-outcome are displayed in columns with a filled-in black circle and a crossed-out circle marking the presence and absence of a condition, respectively. Minimization produced a single, simple path to both the outcome "adaptation" (*OUT*) and the non-outcome: the condition of increased risk perception (*PERC*) on its own is sufficient for the outcome to occur while its absence is sufficient for the non-outcome to occur. These results are highly consistent, non-trivial as indicated by the high total coverage, and not sufficient for the non-outcome as indicated by the high PRI. They are also very robust: Out of ten robustness tests for the outcome, eight produced the exact same solution while the last two produced solutions that are subsets of increased risk perception (*PERC*). As for the non-outcome, five out of ten robustness tests produced the same solution while the remaining five tests produced solutions that are either subsets of the original solution (~*PERC*) or contained at least one pathway that is a subset of the original solution.

Thus, this result is impressive in its simplicity and in line with our third expectation. However, it does not support our three other expectations regarding the roles of recent extreme events *(EVENT)*,

persistent risk exposure *(DANGER),* and adaptation policies at the superordinate level *(STRAT)*. The fact that past extreme events *(EVENT)* are almost a necessary condition for the outcome lends some credence to our first expectation and is in line with recent studies that found the relation between risk perception and risk exposure to be a key factor (Glaus et al., 2020; Herzog & Ingold, 2019). Nevertheless, neither persistent risk exposure *(DANGER)* nor existing adaptation policies and superordinate levels *(STRAT)* seem to be as important as we had expected. Nor do we find any evidence that any interaction effects between our conditions play an important role.

| | **Adaptation** | **~Adaptation** |
|---|---|---|
| | **Path 1** | **Path 1** |
| EVENT<br>DANGER<br>PERC<br>STRAT<br>LEFT<br>RES | ● | ⊗ |
| Consistency | 0.968 | 0.782 |
| PRI | 0.951 | 0.616 |
| Raw Coverage | 0.812 | 0.962 |
| Cases | **Ran**<br>**Täs**<br>**Nik**<br>**Zer**<br>**Leu**<br>**Fli**<br>**Ila**<br>**Lau**<br>**Gut**<br>**Alb** | **Sav**<br>**Sat**<br>**Gst**<br>**Pon**<br>**Ise**<br>**Gri**<br>**Kan**<br>**Bre**<br>**Inn**<br>**Küb** |
| Consistency total | 0.968 | 0.782 |
| PRI total | 0.951 | 0.616 |
| Coverage total | 0.812 | 0.962 |

**Table 16-7: Sufficient combinations of conditions for the outcome adaptation and its complement**

*Note: A full circle denotes the presence of a condition, a circle with a cross inside the absence of a condition. Cases in bold are uniquely covered by that respective path.*

As QCA is fundamentally a qualitative method, it is worthwhile to closely examine individual cases, especially those that do not conform to our solution terms or our expectations. We noted that recent

extreme events (*EVENT*) and perception (*PERC*) are almost necessary conditions for adaptation (*OUT*). The cases where we observed the outcome despite no recent extreme events (*EVENT*) are Diemtigen, Ilanz/Glion, and Täsch. The cases where we observed the outcome despite risk perception being low are Diemtigen, Lautebrunnen, and Bregaglia. What makes these cases special?

Diemtigen and Lauterbrunnen share a common denominator: third parties initiated the primary adaptation measures in both municipalities. In Diemtigen, two engineering bureaus participating in the federally funded pilot program adaptation, geo7, and Sofies-Emac, approached the municipality to discuss a partnership. They selected Diemtigen as an interesting case for geological reasons. Similarly, Lauterbrunnen is an important testing site for a research program by the Swiss federal research institute WSL on the impacts of climate change on Alpine forest management. Their participation in these projects certainly demonstrates some interest in climate change adaptation on the municipalities' parts. Nevertheless, the measures were initiated by third parties who also contributed the lion's share of the required financial and personnel resources. This may explain why these municipalities engaged in adaptation measures despite the absence of otherwise necessary conditions.

Ilanz/Glion was formed in 2014 from the fusion of 13 smaller municipalities, and many facets of its administration are still in development. Climate change is an important item on the political agenda of its municipal council, which is reflected in the city's engagement under the "energy town" label and their awareness of the importance of climate change adaptation (*PERC*). Additionally, like Diemtigen and Lauterbrunnen, Ilanz/Glion was approached by a third party: a master's student of environmental sciences looking to develop an adaptation strategy for Ilanz/Glion for her thesis. Ilanz/Glion was able to benefit from the cooperation with said student and has thus taken adaptation measures despite the lack of extreme events (*EVENT*) in recent years.

In 2017 a major landslide took place in Bondo, a village belonging to the municipality of Bregaglia. It claimed eight human lives, caused 41 million Francs in property damage, and generated a lot of media attention. While experts are divided on whether climate change had any direct influence on the event, it is still somewhat surprising that perceived climate change risk (*PERC*) should be low in a municipality where such a major event took place within the last five years. However, our interview revealed that the main reason the people of Bregaglia do not feel particularly threatened by the impacts of climate change may in fact be the extensive preventive measures taken in the aftermath of the landslide in 2017. Additionally, while the municipality is engaged in many preventive measures that reduce its vulnerability to the impacts of climate change, most are primarily implemented and financed by the canton of Grisons. This explains why we observed adaptation measures (*OUT*) in Bregaglia despite low climate change risk perception (*PERC*).

Lastly, while the municipality of Täsch has had no significant extreme events during the last 10–15 years (*EVENT*), it does have a long history of significant flooding events every 30 years or so with the last significant event taking place in 2001. During the interview, said event was explicitly mentioned as one of the main motivations for the preventive measures that the municipality is now taking. As the event happened more than 15 years ago, Täsch was not calibrated as a case in which a significant extreme event recently took place. However, a closer examination showed that past extreme events are nevertheless an important motivating factor for current measures that reduce the municipality's vulnerability to climate change. Thus, a closer examination of these cases shows, that extenuating circumstances may explain these outliers without truly contradicting any of our primary results.

## 16.9 Discussion and Conclusions

In this paper, we investigate why municipalities adopt climate change adaptation measures to reduce their vulnerability to climate risks. We focus on natural hazards that are particularly relevant and cause major damage in Alpine regions: flooding, mudflows, avalanches, and rockslides (BAFU, 2012; EEA, 2009; Köllner et al., 2017). We studied 21 potentially vulnerable Alpine Swiss municipalities. We then answer the question of what factors enable municipalities to adopt climate change adaptation measures, focusing on four conditions deduced from the literature as well as two control variables. We expected the following conditions to favour local climate change adaptation: the occurrence of extreme events in the recent past, persistent climate risk exposure in the area, increased climate risk perception by the population and the adoption of climate change adaptation policies by the next higher institutional level.

Our results show that the predominant necessary and sufficient condition is the perception of climate risks by the population. When present or absent, it was necessary and sufficient for a municipality to adopt or not adopt climate change adaptation measures, respectively. Thus, this condition dominated all potential explanatory pathways. This is a very interesting result, as QCA is explicitly applied to allow for a combination of factors and pathways to lead to an outcome. So, in such a study context, if perceptions of risks are dominantly apparent, this shows their significant impact. However, different studies have shown that the different "levels" of perception or acceptance seem key (Dermont et al., 2017): while general support for climate change policy goals in the abstract is usually high, concrete measures are often more strongly opposed (Fesenfeld & Rinscheid, 2021; Mildenberger et al., 2022). As Twecan et al. (2022) show, the key to winning support for concrete measures lies not just in how risk is perceived but also how potential solutions are perceived. Future research could thus focus not only on risks and threats but also on adaptation opportunities and co-benefits (Mayrhofer & Gupta,

2016; Sharifi et al., 2021). In this way, we can see if a more positive framing of the issue enhances the uptake of adaptation measures (Dasandi et al., 2022).

Furthermore, perceptions of risks occurred together with the presence of extreme events in the near past. This shows that an event alone is not enough to induce policy change in general and local climate change adaptation in particular. Research has found that beyond the occurrence of an event, its magnitude and other context factors (such as the overall attention or perception by the population in our case) are crucial to induce any sort of change (Birkland & Warnement, 2014; Giordono et al., 2020). So, to move past the "barriers to adaptation" focus, studies should give room to the combination of several factors in order to see what makes adaptation measures update possible.

As QCA is primarily a qualitative method, one limitation of our approach is that the coding of some edge cases was ultimately up to our personal judgement. This was particularly relevant for the coding of our outcome (*OUT*), which was coded based on whether a municipality had taken climate change adaptation without considering the actual outcomes of such measures in detail, as well as the coding of the control condition resources (*RES*) used in robustness tests, which was mostly coded based on qualitative factors assessed through our interviews. These limitations are also noticeable when examining those cases that do not fit our overall results well: some cases were considered as showing the outcome (*OUT*), but the adaptation measures in question were initiated and largely implemented by third parties independent of the municipalities' interest in adaptation.

This study focused on the local level, arguing that it is also at this level that many climate change effects deploy their impact. Our research enhances our knowledge of the lowest level in a multi-level arrangement of climate policymaking, with the knowledge that the climate actions of municipalities can decisively impact upper levels in one way or the other. Finally, our research shows that even when the conditions for local climate change adaptation are met, local authorities and actors need to be further enabled to realize local climate adaptation measures by shifting resources across levels.

## 16.10 Annex

### 16.10.1

| Municipality | Date of the interview | Interviewee(s) |
|---|---|---|
| Albula | 13.07.2021 | President of the municipality |
| Bregaglia | 13.07.2021 | Municipality Forester & Member of the municipal council - Head of the department for security |
| Diemtigen | 12.05.2021 | Municipality Forester |
| Flims | 30.07.2021 | Head of the municipal building authority |
| Grindelwald | 14.06.2021 | Member of the municipal council - Head of the department for security |
| Gsteig | 29.07.2021 | Member of the municipal council - Head of the department for security |
| Guttannen | 19.05.2021 | President of the municipality |
| Ilanz/Glion | 12.05.2021 | President of the municipality |
| Innertkirchen | 01.07.2021 | President of the municipality |
| Iseltwald | 28.04.2021 | Member of the municipal council - Head of the department for security |
| Kandersteg | 16.06.2021 | Member of the municipal council - Head of the department for security |
| Küblis | 07.06.2021 | President of the municipality |
| Lauterbrunnen | 07.05.2021 | Municipality Forester |
| Leuk | 04.05.2021 | Member of the municipal council - Head of the department for security |
| Pontresina | 01.06.2021 | Municipal Scribe |
| Randa | 07.07.2021 | President of the municipality |
| Saviese | 04.05.2021 | President of the municipality |
| Schattenhalb | 29.06.2021 | Vice-president of the municipality |
| St. Niklaus | 04.05.2021 | Member of the municipal council - Head of the department for security |
| Täsch | 09.07.2021 | Member of the municipal council - Head of the department for security |
| Zermatt | 08.06.2021 | Member of the municipal council - Head of the department for security |

### 16.10.2 Interview guide: Municipal natural hazard management and climate change adaptation measures

Over the past ten years, has one or more extreme events such as floods, avalanches, rockfalls or mudflows occurred in the area of the municipality?

a) If so, how many, when and where exactly?

b) How big were the damages?

c) Were there any injuries or deaths?

Who or which office is responsible for the local natural hazard management?

a) What resources does this office have?

b) How is natural hazard management integrated into the political structure of the municipality? Is there a separate department for natural hazards or is it part of a larger department?

What measures does the municipality take to deal with natural hazards?

a) What types of measures are represented? (e.g. spatial planning measures, structural measures, ecological measures such as protective forests, renaturation of riverbeds, etc., information campaigns)

b) Are further measures planned in the future or are further measures currently being discussed?

How is the risk of natural hazards perceived by the community population?

a) In your opinion, is this an important topic or is it hardly given any attention?

b) Are the effects of climate change on the intensity and frequency of natural hazards an issue or has it hardly been discussed so far?

Has the municipality considered how it might be affected by the impacts of climate change?

a) Is someone within the local government officially responsible for climate change adaptation?

b) If so, who and what human resources does this person have, or what is the workload for this activity? What's the budget for this topic?

c) Is climate change adaptation included as a strategic goal in any official municipal documents? (e.g. in planning documents, safety guidelines, laws, etc.) If yes, in which ones?

d) Have measures been taken to reduce vulnerability to climate change and adapt to the consequences of climate change and if so, which ones? Are any such measures currently being discussed or in planning?

e) Have you been in contact with cantonal authorities regarding adaptation to the consequences of climate change, or are there documents at cantonal level that were relevant to your discussion of this topic?

f) On whose initiative did the debate on adapting to the consequences of climate change begin?

Who is the municipal executive composed of?

a) How are the different political parties represented in the executive?

b) Has the party-political composition of the executive branch changed in the last ten years?

c) If yes, how?

**Figure 16-1: Histograms of conditions**

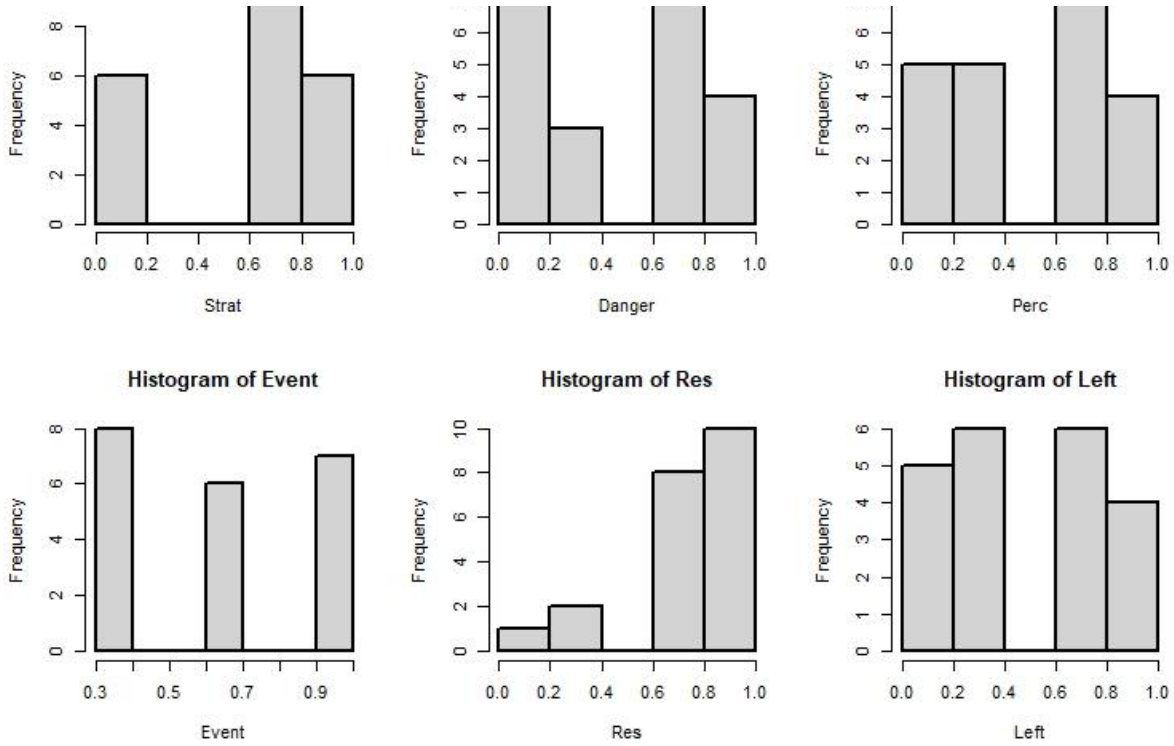

Figure 16-2: xyPlots Conditions and Outcome

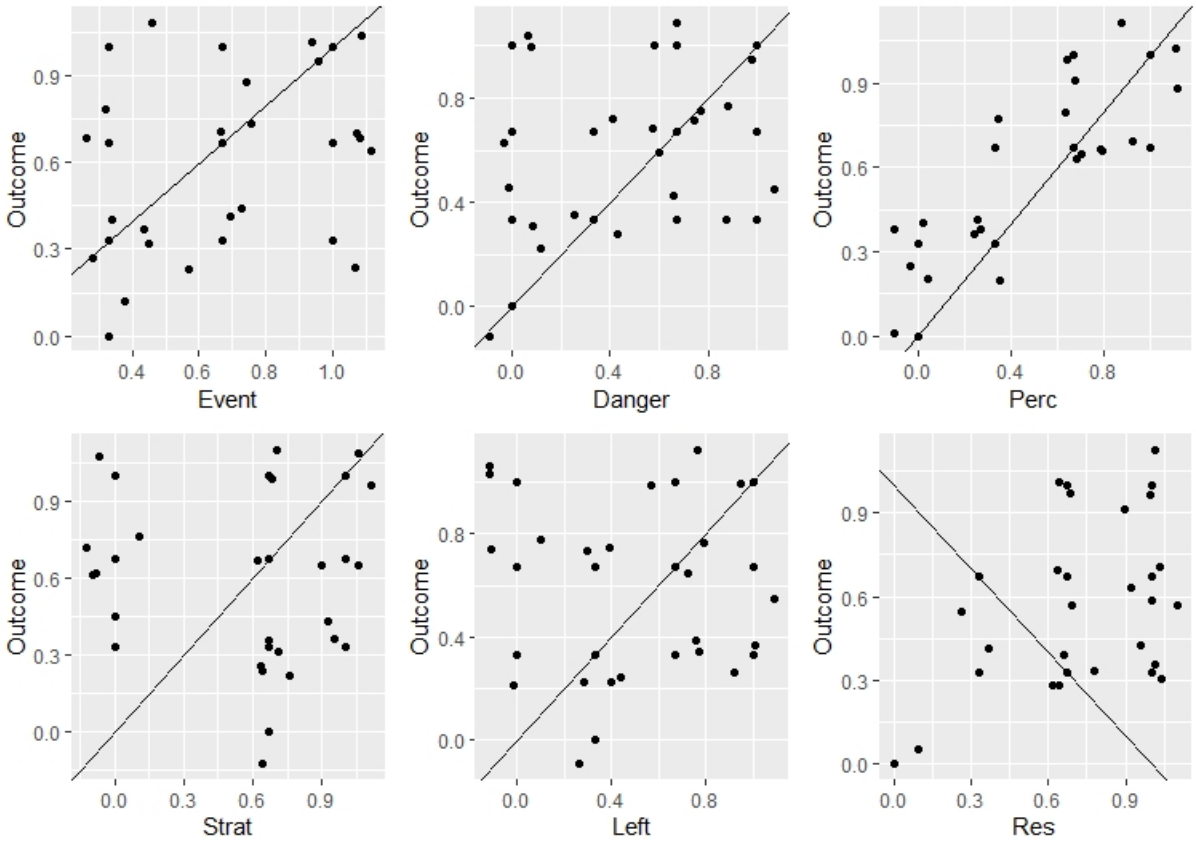

Table 16-9: Conservative solutions for Outcome (M1) and non-Outcome (M2)

| M1: EVENT*PERC + DANGER*PERC + PERC*STRAT -> OUTCOME | | | | | |
|---|---|---|---|---|---|
| | **Consistency** | **PRI** | **covS** | **covU** | **Cases** |
| **EVENT*PERC** | 0.965 | 0.942 | 0.729 | 0.081 | Fli, Nik, Zer, Leu, Gut, Lau, Alb |
| **DANGER*PERC** | 1 | 1 | 0.542 | 0.028 | Täs, Ila, Nik, Zer, Leu, Gut, Lau, Alb |
| **PERC *STRAT** | 1 | 1 | 0.460 | 0.028 | Die, Ila, Fli, Gut, Lau, Alb |
| **M1** | 0.968 | 0.951 | 0.812 | | |

| **M2: perc*STRAT + event*danger*perc -> outcome** | | | | | |
|---|---|---|---|---|---|
| | **Consistency** | **PRI** | **covS** | **covU** | **Cases** |
| **perc*STRAT** | 0.827 | 0.696 | 0.732 | 0.386 | Sat, Gst, Pon, Ise, Gri, Kan, Bre, Inn, Küb |
| **event*danger*perc** | 0.868 | 0.719 | 0.499 | 0.153 | Sav, Sat, Gst, Pon |
| **M2** | 0.852 | 0.718 | 0.886 | | |

Table 16-10: Intermediate and parsimonious solutions for Outcome (M3) and non-Outcome (M4)

*(intermediate and parsimonious solution terms were identical under the directional expectation that the absence of our conditions would lead to the absence of the outcome)*

| M3: PERC => OUTCOME | | | | | |
|---|---|---|---|---|---|
| | **Consistency** | **PRI** | **covS** | **covU** | **Cases** |
| **PERC** | 0.968 | 0.951 | 0.812 | | Die, Täs, Ila, Ran, Nik, Zer, Leu, Fli, Lau, Gut, Alb |

| M4: perc => outcome | | | | | |
|---|---|---|---|---|---|
| | **Consistency** | **PRI** | **covS** | **covU** | **Cases** |
| **perc** | 0.782 | 0.616 | 0.962 | | Sav, Sat, Gst, Pon, Ise, Gri, Kan, Bre, Inn, Küb |

Consistency: sufficiency inclusion score; PRI: proportional reduction in inconsistency covS: raw coverage: How much of the outcome is explained by the respective combination? covU: unique coverage: How much of covS is uniquely attributed to that combination and to no other? The intermediate solution results from logical minimization based on the Quine-McCluskey algorithm. Note: operators for Boolean algebra *=AND, +=OR, => = sufficient for, capital letters: condition is present, lower case letters: condition is absent.

### 16.10.3 Robustness tests

We run a total of ten alternative models as sufficiency robustness tests, including all five alteration types suggested by the literature: Models using alternative selections of conditions, models using alternative consistency and case number thresholds for inclusion in the minimization process, models using alternative case samples and models using differently calibrated conditions (Cooper & Glaesser, 2015; Ide et al., 2020; Schneider & Wagemann, 2012). Five out of these ten alternative models, the ones including different sample sizes and different calibrations, also serve as robustness tests for necessary conditions.

1) We work with two additional control conditions as described in the article – local sympathy for left-wing and environmentalist political parties as indicated by recent national election results (LEFT) and the resources of the local natural hazard management (RES). Based on these two additional conditions we calculate three alternative models: Two including one of the two additional conditions each and a third model including both additional conditions.
2) While for the main analysis we use the consistency thresholds 0.9 and 0.75, both at or above the recommended minimum of 0.75 (Schneider and Wagemann, 2012) and chosen to minimize the number of logical contradictions, we calculate an alternative model with a consistency threshold of 1.0 for both outcome and non-outcome to serve as a robustness test.
3) We also run an alternative model using an alternative frequency threshold, excluding all truth table rows that are not backed by a minimum of two cases.
4) We separate our sample of municipalities into larger municipalities (population >2000) and smaller municipalities (population <2000) and calculate two alternative models based on those two smaller case samples to serve as robustness tests. The threshold of 2000 inhabitants was chosen as it divide the sample as equally as possible (11 and 10 cases respectively).
5) Three final robustness sets are based on different calibration decisions. Firstly, we calibrate the condition risk perception (PERC) based on our interview results only, discounting the survey results that are aggregated at the cantonal level. Secondly, we calibrate the condition persistent risk exposure (DANGER) as measured by official risk maps based on the share of highest risk areas only rather than considering lower risk areas as well. We then calculate one alternative model each with the two differently calibrated conditions and a third alternative model utilizing both the differently calibrated conditions.

The variations based on different sample sizes and different condition calibrations serve as robustness test for our analysis of necessity too. The results of our robustness tests are depicted in tables 1 through 4 below. The robustness tests of necessity indicate that risk perception (PERC) as a necessary condition for local climate change adaptation is not a very robust result while past extreme events (EVENT) as a necessary condition for local climate change adaptation is a much more robust necessary condition. The absence of risk perception as a necessary condition for the absence of the outcome (no local climate change adaptation efforts) is highly robust.

Our robustness tests concerning sufficiency indicate that our results are extremely robust (Schneider and Wagemann, 2012). Out of ten robustness tests for the outcome, eight produced the exact same solution while the last two produced solutions that are subsets of increased risk perception (*PERC*). As for the non-outcome, five out of ten robustness tests produced the same solution while the remaining five tests produced solutions that are either subsets of the original solution (~*PERC*) or contained at least one pathway that is a subset of the original solution.

It should be noted that many of the models we calculated for our robustness tests suffer from serious methodological problems. There are too few cases relative to the number of conditions and/or a high number of logical contradictions. Thus, their results should not be interpreted as standalone models but solely to test the robustness of our primary results.

**Table 16-11: Robustness tests for the necessity analysis for the Outcome**

| | Adaptation (*OUT*) | | | |
|---|---|---|---|---|
| | Consistency | Coverage | Relevance | Robustness |
| *EVENT* | 0.864* | 0.78 | 0.709 | 83.3% |
| *DANGER* | 0.622 | 0.792 | 0.849 | 0% |
| *PERC* | 0.812* | 0.968 | 0.97 | 50% |
| *STRAT* | 0.621 | 0.637 | 0.672 | 0% |
| *~EVENT* | 0.431 | 0.723 | 0.871 | 0% |

| | | | | |
|---|---|---|---|---|
| *~DANGER* | 0.592 | 0.645 | 0.707 | 0% |
| *~PERC* | 0.456 | 0.527 | 0.672 | 0% |
| *~STRAT* | 0.539 | 0.741 | 0.838 | 0% |

**Table 16-12: Robustness tests for the necessity analysis for the non-Outcome**

| ~Adaptation (*~OUT*) | | | | |
|---|---|---|---|---|
| | Consistency | Coverage | Relevance | Robustness |
| *EVENT* | 0.766 | 0.486 | 0.511 | 0% |
| *DANGER* | 0.536 | 0.48 | 0.692 | 0% |
| *PERC* | 0.419 | 0.351 | 0.614 | 0% |
| *STRAT* | 0.732 | 0.528 | 0.612 | 16.7% |
| *~EVENT* | 0.653 | 0.771 | 0.89 | 0% |
| *~DANGER* | 0.768 | 0.588 | 0.675 | 16.7% |
| *~PERC* | 0.962** | 0.782 | 0.817 | 100% |
| *~STRAT* | 0.496 | 0.479 | 0.72 | 0% |

Note: Conditions that meet the 0.9 consistency threshold for necessity are marked with two stars (**), while conditions that meet the 0.8 consistency threshold for necessity are marked with one star (*). Robustness gives the share of consistency scores above 0.8 across all robustness tests.

Table 16-13: Robustness tests for the sufficiency analysis of the QCA for the Outcome

| # | Type | Test | Solution formula | Consistency | Coverage |
|---|---|---|---|---|---|
| 1 | / | primary analysis | PERC -> Outcome | 0.968 | 0.812 |
| 2 | 1 | Additional condition [RES] | PERC -> Outcome | 0.968 | 0.812 |
| 3 | 1 | Additional condition [LEFT] | PERC -> Outcome | 0.968 | 0.812 |
| 4 | 1 | Additional conditions [RES] and [LEFT] | PERC -> Outcome | 0.968 | 0.812 |
| 5 | 2 | consistency threshold 1.0 | PERC -> Outcome | 0.968 | 0.812 |
| 6 | 3 | frequency cut-off 2 | PERC -> Outcome | 0.968 | 0.812 |
| 7 | 4 | Larger municipalities only (population >2000) | PERC -> Outcome | 0.948 | 0.901 |
| 8 | 4 | Smaller municipalities only (population <2000) | PERC -> Outcome | 1.00 | 0.707 |
| 9 | 5 | Condition [PERC] calibrated based on interview data only | (PERC*~STRAT) + (EVENT*~DANGER*PERC) -> Outcome | 0.913 | 0.564 |
| 10 | 5 | Condition [DANGER] calibrated based on proportion of settled areas in highest risk zones only | PERC -> Outcome | 0.968 | 0.812 |
| 11 | 5 | Condition [DANGER] calibrated based on proportion of settled areas in highest risk zones only and condition [PERC] calibrated based on interview data only | (PERC*~STRAT) + (~EVENT*~DANGER*PERC) + (EVENT*DANGER*PERC) -> Outcome | 0.962 | 0.671 |

* = and ; + = or ; ~ = absence of ; -> = sufficient for ; ↔ is substituted for

Table 16-14: Robustness tests for the sufficiency analysis of the QCA for the non-Outcome

| # | Type | Test | Solution formula | Consistency | Coverage |
|---|---|---|---|---|---|
| 1 | | primary analysis | ~PERC -> ~Outcome | 0.782 | 0.962 |
| 2 | 1 | Additional condition [RES] | (~EVENT*~PERC) + (DANGER*~PERC) -> ~Outcome | 0.841 | 0.807 |
| 3 | 1 | Additional condition [LEFT] | ~PERC -> ~Outcome | 0.782 | 0.962 |
| 4 | 1 | Additional conditions [RES] and [LEFT] | M1: (~EVENT*~PERC) + (~PERC*~LEFT) + (DANGER*~PERC) -> ~Outcome<br>M2: (~EVENT*~PERC) + (~PERC*~LEFT) + (~RES*~PERC) -> ~Outcome | 0.823<br>0.886 | 0.885<br>0.885 |
| 5 | 2 | consistency threshold 1.0 | ~EVENT*DANGER*~PERC -> ~Outcome | 1 | 0.344 |
| 6 | 3 | frequency cut-off 2 | DANGER*~PERC -> ~Outcome | 0.867 | 0.498 |
| 7 | 4 | Larger municipalities only (population >2000) | M1: ~EVENT*~STRAT -> ~Outcome<br>M2: ~DANGER*~STRAT -> ~Outcome<br>M3: ~PERC*~STRAT -> ~Outcome | 0.801<br>0.751<br>0.834 | 0.399<br>0.598<br>0.498 |
| 8 | 4 | Smaller municipalities only (population <2000) | ~PERC <-> ~Outcome | 0.763 | 1 |
| 9 | 5 | Condition [PERC] calibrated based on interview data only | ~PERC -> ~Outcome | 0.696 | 0.809 |
| 10 | 5 | Condition [DANGER] calibrated based on proportion of settled areas in highest risk zones only | ~PERC -> ~Outcome | 0.782 | 0.962 |
| 11 | 5 | Condition [DANGER] calibrated based on proportion of settled areas in highest risk zones only and condition [PERC] calibrated based on interview data only | ~DANGER*~PERC -> ~Outcome | 0.873 | 0.579 |

* = and ; + = or ; ~ = absence of ; -> = sufficient for ; ↔ is substituted for

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Zürich, 28.10.2022

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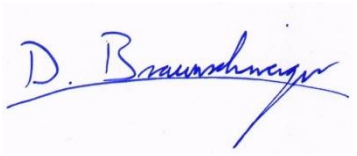

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