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Source: Mountain Research and Development, 33(3):225-233. 2013.
Published By: International Mountain Society
DOI: http://dx.doi.org/10.1659/MRD-JOURNAL-D-13-00004.1
URL: http://www.bioone.org/doi/full/10.1659/MRD-JOURNAL-D-13-00004.1

Mountain Research and Development (MRD)
An international, peer-reviewed open access journal
published by the International Mountain Society (IMS)
www.mrd-journal.org

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Exploring Water Governance Arrangements in the Swiss Alps From the Perspective of Adaptive Capacity

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In times of increasing uncertainty because of climate and socioeconomic changes, the ability to deal with uncertainty and surprise is an essential requirement for the sustainability of alpine water governance. This article aims to contribute to the understanding of the adaptive capacity of water governance arrangements in the Swiss Alps and to propose options for reforms. To this purpose, we evaluated the current arrangements and the ways the actors have dealt with water shortages in the past, based on qualitative interviews and a document review. The research revealed that the adaptive capacity of the investigated arrangements is rather high with regard to reactive ways of responding to water shortage problems. However, there is limited capacity to proactively anticipate possible changes and to find prospective solutions on a regional scale. We conclude that with increased environmental and social pressures, forms of proactive water resource governance should be introduced, taking into account the welfare of people in both upstream and downstream areas.

Keywords: *Water governance; adaptive capacity; reform options; reactive and proactive responses; Switzerland.*

Peer-reviewed: *April 2013* ***Accepted:*** *May 2013*

Introduction

In future, the supply and consumption of water in highland and lowland areas may be significantly modified by both climate change and socioeconomic developments. Consequently, existing conflicts of interest are likely to be fueled and conflicts are likely to be created. Dry valleys in the European Alps will be particularly affected. It must be assumed that in these regions, the general water supply will become even scarcer and seasonal distribution may change significantly (Beniston et al 2011). Numerous signs of climate-driven changes in the Alps have already been observed, as exemplified by the general retreat of mountain glaciers (Beniston et al 2011; Viviroli et al 2011).

Water resources are of central importance to the prosperity and development of Alpine societies. In many Alpine regions, water is a fundamental pillar of the local economy, which is often built on tourism, agriculture, and hydropower production. Economic, tourism, and urban development in the last decades have resulted in increasing water demands (Reynard and Bonriposi 2012). Moreover, specific characteristics of mountain water governance arrangements—such as asymmetries between upstream and downstream users (van der Zaag 2007) and territorial complexities with cross-cutting political, social, land use, and hydrological boundaries (Reynard 2000)—pose additional challenges. Against this background, current water governance arrangements and practices in these regions have to be fundamentally reconsidered to guarantee their sustainability.

By sustainable water governance, we understand the process that involves all relevant stakeholder groups in coordinating water-related activities in a way that ensures social and economic welfare without compromising the viability and integrity of the supporting hydroecosystems in the long-term (Wiek and Larson 2012). Water governance arrangements encompass formal and informal institutions such as laws, regulations, property rights, policies, and social norms, as well as practices (Hill 2013). In times of increasing uncertainty because of climate and socioeconomic change, the ability to deal with uncertainty and surprise is an essential requirement for the sustainability of governance arrangements (Pahl-Wostl 2009). Thus, trying to assure sustainability of governance arrangements in the long term requires drawing attention to their adaptive capacity (Engle 2011).

The concept of adaptive capacity has received significant attention in studies on climate change adaptation (Engle 2011). Following Hill (2013), Adger et al (2005), and others, in this study we define adaptive capacity as the capacity of actors to create and respond to variability and change in the state of the system in both proactive and reactive ways. Proactive responses are particularly important, because they allow anticipation of

and influence on future water problems. In other words, creating adaptive capacity is about creating options now and in the future, rather than limiting them (Hill 2013), by creating flexibility (Hurlbert 2009) as well as connectivity and trust among actors (Folke et al 2005). Empirical studies have found that adaptive capacity is influenced by actors' access to financial, human, and social resources (Olsson et al 2006; Babel et al 2011), as well as to knowledge and information (Engle and Lemos 2010). Moreover, there is growing agreement that for anticipating potential problems and developing farsighted solutions, high learning capacity is needed (Tompkins and Adger 2004; Folke et al 2005; Olsson et al 2006; Pahl-Wostl et al 2007). Learning by judicious doing represents a departure from the more traditional approach of rigid and irreversible planning and management to a concept of policy experimentation, social learning, and scenario planning. This is especially important because the future may bring changes that are not susceptible to past and present coping strategies (Hill 2013).

This study contributes to the debate by exploring water governance arrangements and practices in a Swiss Alpine region. The overall aim is to identify options for meaningful water governance reforms from the perspective of adaptive capacity.

Approach

We evaluated the water governance arrangements of the Crans-Montana-Sierre region and the ways actors there have dealt with water shortages in the past. In doing so, we assumed that water shortages might become more frequent in the future under conditions of climate and socioeconomic change. The study is based on a qualitative research perspective (Flick 2005). As a first step, we analyzed the basic features of the region's water governance arrangements, which included the actor configuration, legislative framework, water rights situation, and origins and transfers of water flows. Second, we explored water-related practices from decision making through implementation, with a special focus on people's responses to water shortage crises. For these two steps, we conducted semistructured interviews with key actors involved in water governance (members of municipal institutions, interest groups, and local businesses) and participatory observation during local public meetings related to water issues. Moreover, we drew on an extensive review of documents, including local reports and newspaper articles, case-specific scientific studies, laws, regulations, and agreements. This information was systematized and assessed to identify the most important characteristics of existing adaptation practices. Based on this assessment, we identified 5 key elements that build the adaptive capacity of the arrangements. Finally, we deduced options for water governance reforms and discussed them with the stakeholders.

Case study: the Crans-Montana-Sierre region

The 11 communes of the study region are located in one of the driest parts of Switzerland, in the canton of Valais, on south-facing slopes with a considerable difference in altitude (from 500 masl in Sierre to 3000 masl on the Plaine Morte Glacier). They are limited in the west by the Lienne River and in the east by the Raspille River. All 11 communes are organized in the district of Sierre. The tourism resort of Crans-Montana belongs to the 6 communes that make up the High Plateau, whereas the 5 other communes are located downstream on the hillsides or in the Rhone plain (Figures 1 and 2). There is a strong hydrological gradient; the difference between precipitation and evapotranspiration averages about 150 mm/y in Sierre and more than 2200 mm/y at high elevations. The region occupies 4 main watersheds and is drained by several small streams flowing toward the Rhone River. The discharge of meltwater from the Plaine Morte Glacier is an important water resource for the region, but the glacier is projected to retreat considerably over the next decades and even to disappear by 2080 (Finger et al 2013). While the 11 communes depend on water from the same higher mountain areas and are part of the same administrative district, the water resources of each municipality are highly variable (Bonriposi 2013). The prevailing water shortage problems are described later.

Basic features of the water governance arrangement

In Switzerland, all administrative levels (the confederation, cantons, and communes) are involved in water governance. There is extensive federal legislation related to water (Schweizer Eidgenossenschaft 2013). However, Swiss cantons still exercise a great deal of political influence and power, and the administrative configuration in the field of water policy clearly echoes the federalist structure of the Swiss political system. Within this overall structure, the confederation establishes principles for the use and protection of water, and the cantons are left to decide on its disposal within the framework of the existing law. The canton of Valais delegated this competence to the communes with the exception of the Rhone River. The communes thus have the right to dispose of and to use the public water bodies within their boundaries. This includes the right to grant water use rights such as concessions to other users (Mauch and Reynard 2004).

However, water supply and use are governed not only by public legislation but also by private property rights, several hundred ancient water rights going back to the 14th century, and a multitude of formal and informal agreements (Table 1). By informal agreements we mean

FIGURE 1 Part of the Crans-Montana-Sierre region. In the middle is the tourism resort of Crans-Montana, with several reservoirs, golf and skiing areas are in the background, the Tseuzier reservoir is at the top left, and agricultural and settlement areas at the lower right. (Photo courtesy of Schweizer Luftwaffe)

agreements that have not been formalized, for example, through a written contract; this includes customary law. Sometimes, these agreements are so deeply rooted among the actors involved that they become a tacit understanding.

Figure 3 gives an overview of the overlapping institutions governing the main water flows on a regional level. The figure represents a schematized map with the borders of the main catchments, the water sources (eg springs and rivers) of the different communes, and the main relationships among the communes. The figure clearly shows a lack of horizontal and vertical integration (Reynard 2000). There are 3 separate infrastructure networks (High Plateau, Sierre, and St-Léonard) and 4 groups of communes that regularly share water through agreements. Upstream and downstream communes are only linked through shared water rights related to the rivers. Moreover, as the figure shows, the communes have unequal access to water. For instance, although some communes have guaranteed water rights on the main rivers or many springs (eg Iconge, Mollens, and Randogne), others (eg Veyras) possess few or no rights and consequently depend heavily on agreements with water-rich communes.

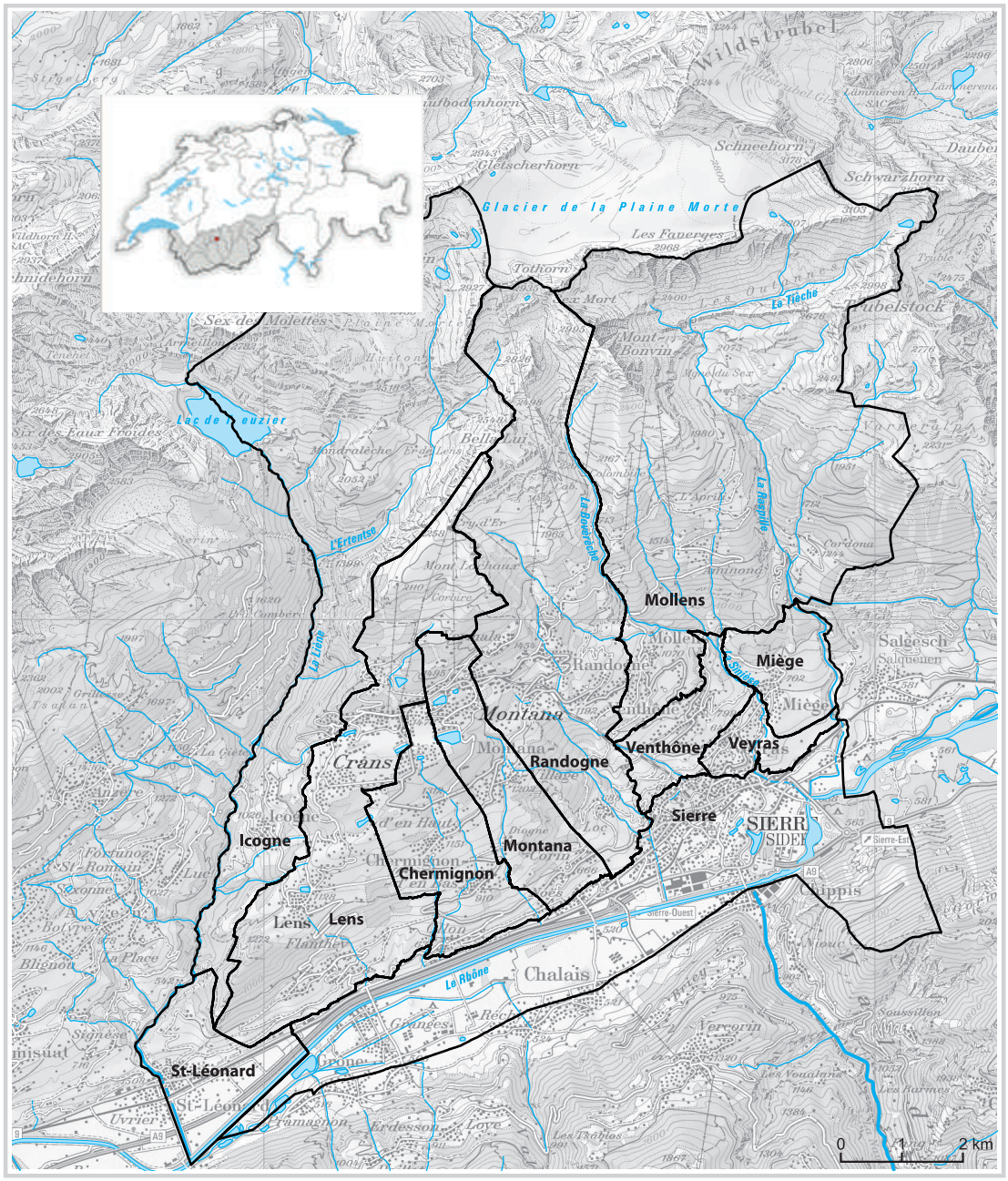
Another key feature of the current water governance arrangements is the diversity of actors—municipal authorities responsible for the supply of drinking water; the hydroelectric power company, in charge of the biggest reservoir; the common-property irrigation corporations (*consortages*), responsible for smaller reservoirs, irrigation channels, and irrigation water; the local institutions combining traditional owners selected to administer village resources (*bourgeoisies*); and finally, tourism entrepreneurs—eg the ski lift company that needs water for artificial snow production—that are among the most important economic players in the region.

The high institutional density, the multitude of overlapping entitlements, and an inherent difficulty in obtaining signed legal documents results in a heterogeneous, confusing, and often opaque water governance situation.

Water shortage problems

For centuries, water has been a crucial issue for the people living in the region and has often been the focus of competitive and sometimes subtle struggles among actors trying to gain access to more water (Ammann 2011).

FIGURE 2 The 11 communes of the Crans-Montana-Sierre region. (Map by Flurina Schneider, based on sources from SwissTopo)



While there is an abundance of water in the higher mountain areas and around the main rivers, the slopes where people live and work are very dry. Consequently, the need for drinking and irrigation water has always been an important concern. Documents from the 14th century report huge efforts to divert water from the water-rich mountain areas to the farming villages on the dry slopes (Quaglia 1988; Ammann 2011). At that time, water was mainly used for domestic and agricultural purposes. There are also numerous historical case records and judgments demonstrating conflicts, sometimes armed, over the scarce resource. Conflicts often arose when parties with increasing water needs diverted water from rivers with unclear water rights situations, such as the Raspille River (Ammann 2011).

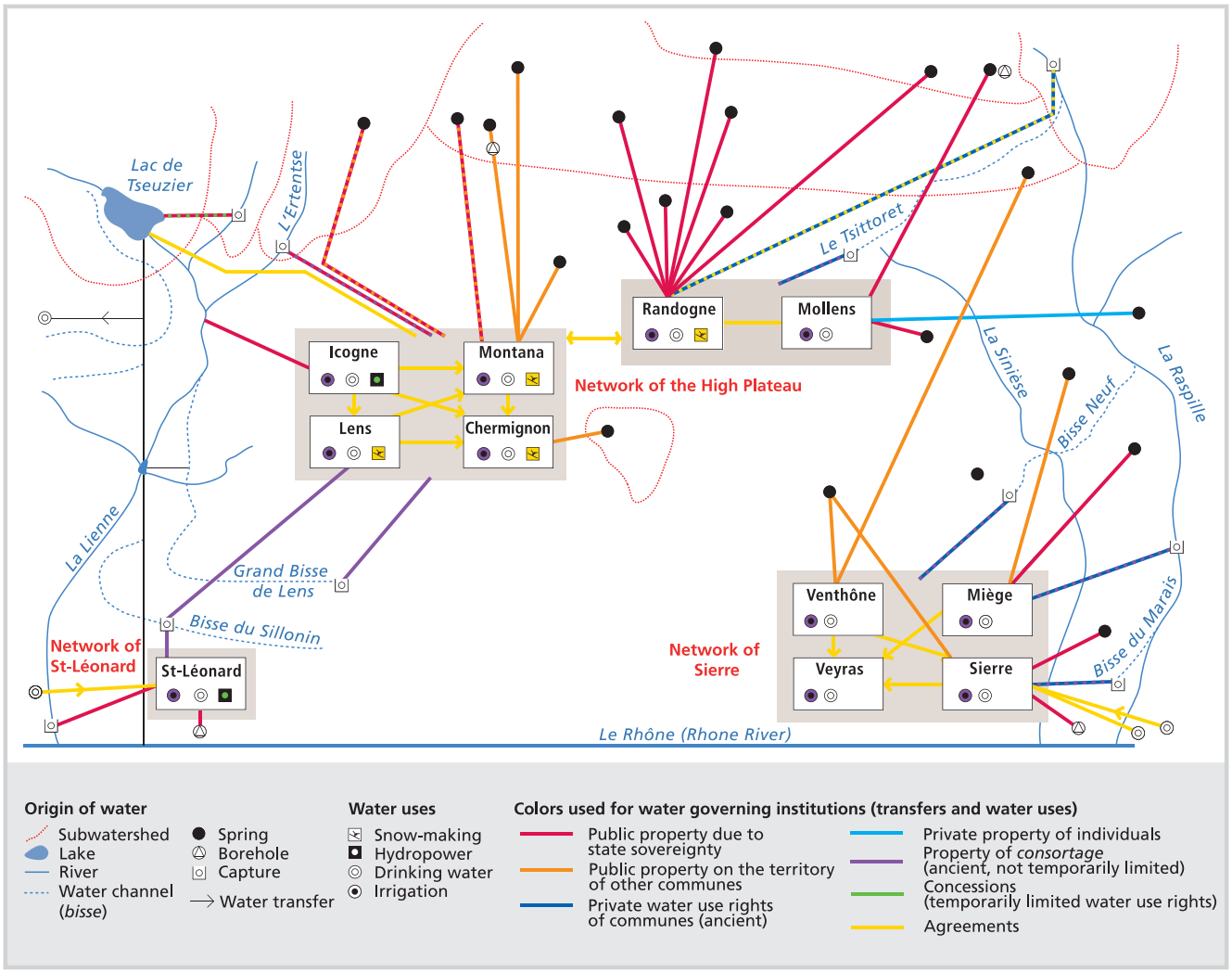
In the 20th century, water shortage problems were shaped by increasing water needs related to socioeconomic changes. In the High Plateau, medical and

TABLE 1 Formal and informal elements of water governance.

Formal elements	Legislation
	Property and water use rights
	Concessions
	Formalized agreements such as contracts
Informal elements	Nonformalized agreements
	Customary law
	Tacit understandings

sports tourism started to develop in the first decades of the 20th century and resulted in a significant construction boom from 1960 onward. In parallel, population growth, intensification of agriculture, viticulture, and hydropower production increased water needs (Reynard 2000). From 1960 onward, local media outlets and residents reported about 10 serious water shortages. Problems included periodic shortages of

FIGURE 3 Institutions governing water distribution in the 11 communes of the Crans-Montana-Sierre region. (Illustration by Flurina Schneider)



drinking water, especially in the lower villages and the tourism resort on the High Plateau (mainly before 1970), and of irrigation water for agriculture, viticulture, and domestic gardens. Most water shortages occurred in summer when the water demand for agriculture is highest. In dry years such as 2003, farmers were not able to irrigate for the second mow and consequently had to buy expensive fodder from abroad. Most water shortages affected only an individual commune or sector, not the region. This shows that they were mainly because of the uneven distribution of and access to water rather than the quantity of water available.

Although in the recent past, it was possible to deal with water shortages (explained later), a major source of concern today is related to the unclear effects of climate change; the often opaque water rights situations, which hinder innovative projects; and the rising water demand caused by socioeconomic developments. A recent study predicted that water demand could still rise considerably, especially if socioeconomic growth continues (Bonriposi 2013).

Adaptation to water shortages

An analysis of how various actors dealt with water shortages in the past and the resulting water governance arrangements revealed 5 key dimensions related to adaptive capacity: material and financial capital, collaborative capacity, institutions and entitlements, resource efficiency, and learning capacity.

Material and financial capital

In most cases, people responded to water shortages by increasing investments in infrastructure including intakes, stream diversion pipelines, tunnels, reservoirs, and even water pumping stations. Infrastructure-based solutions go back to the 14th century, when people built the first water channels (*bisses*) to divert water from water-rich mountain areas to farming villages on the dry slopes (Quaglia 1988; Ammann 2011). In the last decades, two particularly important infrastructure projects were the construction of the Tseuzier hydropower reservoir and the Mt-Lachaux tunnel. The reservoir, situated in a water-rich catchment, made it possible to retain water for times of higher demand. The tunnel linking two catchments allowed better transfer of water from the reservoir to the villages and the tourism resort regularly suffering from water shortages (Bréthaut 2012). These projects solved many water shortage problems and continue to be effective.

Although in the past water sometimes had to be transported by trucks to the communal reservoirs (Commune de Lens 2013), today the adaptive capacity based on infrastructure is rather high. The extensive water supply and distribution infrastructure makes it possible to exploit the available water resource and to flexibly divert it to the places where it is needed. Thus, through the water infrastructure network, rather high levels of both connectivity and flexibility are obtained. However, there are 3 separate drinking water distribution networks, and this separation prevents water sharing between upstream and downstream communes (see Figure 2). This is particularly disadvantageous for downstream communes that have no major rivers or other water sources on their own territory (eg Veyras).

Investment in water infrastructure has been possible because of the relatively high availability of labor in the past and financing today; but some communes also went into debt (Quaglia 1988). Generally, high financial capital allowed actors that needed water to buy it from others with a surplus (water-rich communes, *consortages,* or private businesses such as the hydropower company). There is an extended water market in the region, which has made it possible to mitigate or solve many local water shortages. However, prices are rather high, especially for water provided by the hydropower company. Moreover, water users who create low economic added values, such as farmers, cannot profit from the water market in the same way.

Collaborative capacity

Over the centuries, collaboration has been a crucial element in adaptation strategies, whether for constructing and maintaining infrastructure or organizing water uses such as irrigation and water transfers and purchases. Today, there are 3 main forms of collaboration: the traditional *consortage,* ad hoc bilateral arrangements, and intercommunal associations.

The *consortages* are mainly responsible for constructing and maintaining traditional irrigation channels, as well as distributing water among their members. Members include water users along certain water courses (eg traditional *bisses*) or in certain catchments (eg alpine pastures). Various historical documents give evidence of the elaborate ways collaboration was organized in traditional *consortages* (Dussex 2011; Papilloud 2011). But their role, and consequently the high collaborative capacity within them, is weakening because of socioeconomic transformations (Reynard and Bonriposi 2012).

With the growing number of different water uses and the increasing water demand, especially by the tourism resort, the communes had to play a major role in the organization of the water supply. As a consequence, they started to mediate between and collaborate with other communes or water users, mostly in bilateral arrangements. Collaborations took on various forms, including joint construction and use of pipelines and reservoirs, building of infrastructure on the territory of other communes, and agreements about water sharing (eg ceding water rights or exchanging them for the right to build a pipeline on the territory of the other commune). Most often, collaboration started on an ad hoc basis to

address an immediate demand or conflict and was based on the immediate interests of the parties involved.

These ad hoc agreements resulted in a high level of bilateral connectivity and flexibility. However, few such collaboration efforts embrace all communes in the region, both upstream and downstream. Only in recent years have intercommunal associations been funded as a response to water crises (Reynard 2000; Bréthaut 2012). So far, the results of these associations are often rather limited, and there is no association linking all communes and major water users of the region. For example, there is no regional emergency plan for water governance in times of drought. Moreover, there has been limited success in defining joint visions for future proactive responses to water problems. People interviewed for this study pointed to lack of trust and fear of losing autonomy as two important reasons for the limited results and successes.

Institutions and entitlements

Access to water is governed by overlapping entitlements based on legislation, ancient water use rights, and other formal and informal agreements. The formal elements of this institutional structure provide predictability and certainty, but they are relatively inflexible and difficult to change. This is especially true of ancient water rights (including nonformalized customary law) that have endured for centuries. They are generally limited to certain quantities (in volume or hours or percentages) or certain uses (especially irrigation) but remain valid indefinitely without an expiration date. An eloquent example is the *Edit de Silennen* of 1490, in which the bishop of Silennen divided the waters of the Raspille River among the communes. While these water rights reflected the needs of the people in the 14th century, they do not reflect current needs related to tourism and hydropower production. Renegotiation of these ancient rights depends on the willingness of all parties involved. One such endeavor recently failed because of the resistance of one of the communes involved (Reynard 2000).

Only one major formal water right has a limited duration: the concession for hydropower production. This concession, which is based on current legislation, allows the company to use the total amount of water of the defined catchment for 80 years. Thus, its renewal in 2037 will make it possible to introduce more flexibility and fundamentally rebuild the current water distribution system.

While the formal elements of the institutional structure are hard to change, in several cases actors have used existing room for maneuver within these structures to flexibly negotiate case-by-case agreements. A prominent example is the renegotiation of ancient water rights to develop the hydropower concession. In this case, the *consortage* holding the ancient water rights abandoned those rights on the conditions that the hydropower company take over infrastructure maintenance and guarantee a certain amount of water, which even has to be pumped to the traditional water channel in case of a water shortage (Bréthaut 2012). There are numerous other agreements among communes and with private companies, yet it is difficult to access the signed documents. They are widely referred to but rarely seen by decision makers.

Not all such negotiations have been successful. In several cases, adaptive solutions were hindered by disagreements among the concerned legal units (eg in the attempt to renegotiate water rights to the Raspille River). Moreover, communes heavily depending on ad hoc negotiated agreements with limited certainty are vulnerable: Water transfers have been stopped when the selling commune's needs were jeopardized (Quaglia 1988).

There have also been reports of illegal diversions of water during a shortage (Commune de Lens 2013). According to comments made during the interviews for this study, this still occurs, and although it is not officially tolerated, there are usually no penalties imposed and it is usually not directly challenged by the people involved. Thus, it can be regarded as an informal agreement among actors.

An assessment of adaptive capacity based on the current institutions and entitlements provides ambiguous results. On the one hand, the existing institutional structure provides considerable room for maneuver in that it has allowed people to successfully negotiate solutions to many water shortage problems. However, on the other hand, the institutional structure itself is rather inflexible because of its strong historicity, predefined uses, and legal obscurity. Considering the unequal distribution of water rights, this situation tends to disadvantage water-poor communes and prevent more radical adaptation to newly emerging needs. Thus, it hinders more visionary approaches that take the welfare of people in the whole region into consideration.

Resource efficiency

All practices described so far aim to manage the water supply to increase availability. There have been only a few efforts to solve water shortage problems by managing water demand, for example, by promoting more efficient irrigation (drip irrigation), separating the drinking and irrigation water infrastructure, or eliminating water loss by repairing leaks. Only in times of acute water crises are there widespread efforts to temporarily save water, for example, by prohibiting agricultural and garden irrigation or car washing. In these cases, the communes and *consortages* are entitled to occasionally restrict water consumption proportionally to the amount available.

Consequently, there is little effort to build adaptive capacity by increasing the efficiency of resource use through demand management; however, the potential of this approach is high. For example, Bonriposi (2013) found huge differences in water use efficiency among the

communes. Furthermore, and most important, regional planning (eg for the construction of tourism infrastructure) most often takes place without fundamentally considering the related increase in water demand on a regional scale, which creates water use structures and water needs that may in the future limit the room for maneuver.

Learning capacity

The extensive experience in dealing with water shortage problems has provided key actors in this sector with various opportunities to learn by doing, and their ability to continuously solve water shortage problems proves their learning capacity. However, that learning is mostly limited to improving the performance of existing institutions and structures. Responses to water shortage problems follow the same philosophy of water supply management that strives for local solutions based on infrastructure, water use rights, and ad hoc agreements, as described earlier. However, proactive water governance that anticipates and influences future water problems should also involve reflections and actions that transform the underlying norms of interaction and address the conditions that structure these norms (Pahl-Wostl et al 2007). Lack of trust, lack of transparency, inadequate monitoring and assessment (most communes do not know how much water they use for different purposes), as well as inadequate provision for learning and knowledge exchange on a regional scale hinder this kind of learning.

Conclusions

This paper assessed the water governance arrangements of the Crans-Montana-Sierre region through the lens of adaptive capacity. The analysis showed that in past people responded to water shortage problems by improving the supply of the resource through investments in the infrastructure (drawing on material and financial capital) and multiple forms of collaboration, especially at the local and sectoral levels (drawing on collaborative capacity). By doing so, they amended the formal framework of institutions and entitlements based on existing legislation and ancient water rights with a multitude of agreements. Thus, what could be interpreted at a first glance as a rigid formal institutional framework has proved flexible in finding step-by-step solutions.

However, the adaptive capacity of communes with substantial water rights is much higher than that of communes with marginal water rights. Moreover, existing arrangements have not facilitated proactive and visionary regional solutions based on the welfare of people in both upstream and downstream areas because of limited collaborative and learning capacity on a regional level. While there have been many instances of collaboration and learning within and among neighboring communes, this is not the case on a regional level.

We conclude that the adaptive capacity in the Crans-Montana-Sierre region is based primarily on reactive, ad hoc, local solutions but rarely on proactive, regional responses. The flexibility of the arrangements is relatively high, whereas the levels of connectivity and trust are relatively low. The governance of the resource is based on measures related to supply management, not on reorganization or improved structuring of water use.

Until now, formal and informal coordination and cooperation among water-governing entities, combined with supply-oriented water management (relying on the depletion of the water resource through a massive infrastructure investment to cope with the demand) shows that the system is adaptive to a limited extent, because a fundamental requirement is the longevity of the actors in place, who are more reactive than proactive. Will these arrangements also work under further climate and socioeconomic changes and the resulting pressure of a diminishing resource-to-demand ratio? We argue that the adaptive capacity of the current water governance arrangements could be improved by taking the following steps:

- More emphasis should be placed on collaboration, learning, and demand management at the regional level. This could include proactive and participatory processes of strategy development to harmonize regional development with water governance for upstream and downstream communes (as is now done within the group of upstream communes). For example, thematic teams (to address water resources, energy resources, and other issues) could be created, defined by an organization of stakeholders into cooperative undertakings, with a common goal: sustainable water governance for the region.
- To allow more proactive and regional solutions, key variables, especially regarding water use quantities and costs, should be monitored, and relevant information should be made available in a transparent and accessible way to the 11 communes of the area.
- Water governance measures should take advantage of the room for maneuver provided by the existing formal regulatory framework. For example, it is necessary to agree now on a truly regional vision to achieve a judicious restructuring when the hydropower concession comes up for renewal in 2037. Such an approach, based on the reservoir's multifunctionality, will make it possible to take into account the water demands of different users and communes and to better integrate local stakeholders into the broader legal and institutional framework.
- The water rights situation has to be clarified and made transparent. Reflection should be encouraged on how water rights can be renegotiated, taking into account the welfare of all people in the region rather than the

particular interests of individual actors. In doing so, emphasis has to be placed on improving the situation of communes with few or no water rights.

These recommendations have been discussed with regional decision makers. While they consider the lack of transparency in the legal situation to be the most striking problem, and many stress the need for water rights reform, they do not see possibilities for renegotiating current water rights because of the resistance of the rights owners. Thus, ways to approach this and other problems have to be further discussed with actors of different administrative levels and expertise to achieve fair and effective solutions that take changing natural and social conditions into account.

ACKNOWLEDGMENTS

We thank the MontanAqua research team and the members of the stakeholder group RegiEau for their continuous assistance, fruitful discussions, and inspiring collaboration, as well as the editors of this journal and two anonymous reviewers for their comments. We also thank the Swiss National Science Foundation for funding the research through the National Research Programme "Sustainable Water Management" (NRP 61).

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