www.water-alternatives.org Volume 8 | Issue 2

Schneider, F. 2015. Exploring sustainability through stakeholders' perspectives and hybrid water in the Swiss Alps. Water Alternatives 8(2): 280-296

Exploring Sustainability through Stakeholders' Perspectives and Hybrid Water in the Swiss Alps

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ABSTRACT: Can the concept of water as a socio-natural hybrid and the analysis of different users' perceptions of water advance the study of water sustainability? In this article, I explore this question by empirically studying sustainability values and challenges, as well as distinct types of water as identified by members of five water user groups in a case study region in the Swiss Alps.

Linking the concept of water as a socio-natural hybrid with the different water users' perspectives provided valuable insights into the complex relations between material, cultural, and discursive practices. In particular, it provided a clearer picture of existing water sustainability challenges and the factors and processes that hinder more sustainable outcomes. However, by focusing on relational processes and individual stakeholder perspectives, only a limited knowledge could be created regarding a) what a more sustainable water future would look like and b) how current unsustainable practices can be effectively transformed into more sustainable ones.

I conclude by arguing that the concept of water as a socio-natural hybrid provides an interesting analytical tool for investigating sustainability questions; however, if it is to contribute to water sustainability, it needs to be integrated into a broader transdisciplinary research perspective that understands science as part of a deliberative and reflective process of knowledge co-production and social learning between all actor groups involved.

KEYWORDS: Hybrid water, stakeholder perceptions, water sustainability, Switzerland

INTRODUCTION

Interdisciplinary and transdisciplinary perspectives on water sustainability

Unsustainable governance of water resources is increasingly posing development challenges to countries in the global South and North. These challenges include resource scarcity, long-term degradation of resources, a deterioration in their quality, unequal access to, and distribution of, resources, a lack of adaptive capacity, and related consequences for people's livelihoods and community budgets (Alcamo et al., 2007; Pahl-Wostl, 2007; Wiek and Larson, 2012).

However, what a more sustainable water future might look like is not uncontested. According to the Brundtland Report, sustainability refers to development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: chapter 2, point 1). This definition is highly normative and abstract. Distinct stakeholder groups can have very different and even conflicting views on what might be more sustainable solutions (Leach et al., 2010; Pahl-Wostl et al., 2007). For this reason, sustainability scientists suggest including the normative dimension of sustainability to a greater degree in respective research endeavours (Miller et al., 2014) and to conceptualise sustainable water governance as a process that involves all relevant stakeholder groups (Reed and Kasprzyk, 2009; Wiek and Larson, 2012; Schneider and Rist, 2013). Nonetheless, many water studies referring to sustainability have equated sustainability exclusively with good ecological outcomes or long-term preservation of water resources, without looking at its other dimensions.

Sustainability scientists also generally agree that the assessment of water sustainability requires inter- and transdisciplinary research approaches that link the knowledge and perspectives of various scientific disciplines as well as non-academic stakeholders (Lang et al., 2012; Schneider and Rist, 2013). They consider this necessary because sustainability is about harmonising ecological, economic and social issues. Yet fairly few studies analyse water sustainability from a truly holistic perspective, taking into account different kinds of knowledge as well as the dynamic relationships between biophysical, social and economic dimensions of sustainable development (Wiek and Larson, 2012). Instead, many scientific studies are limited to producing disciplinary knowledge and investigate social, economic, and natural dimensions of sustainability independently of one another. For example, natural scientists study aspects of the hydrological cycle, while social scientists explore issues of water use and management.

Water as a socio-natural hybrid

In recent years, political ecologists and anthropologists developed an approach to water that recognises it as a socio-natural hybrid. This understanding of water is closely linked to the idea of a hydrosocial cycle, which likewise takes into account the inseparability of social and physical aspects of water (Linton, 2008; Budds, 2009; Swyngedouw, 2009; Bakker, 2012; Linton and Budds, 2014). Linton and Budds (2014: 1) define the hydrosocial cycle as "a socio-natural process by which water and society make and remake each other over space and time". An important aspect of this framework is that it does not view water and society as separate entities that reciprocally shape each other – as many studies applying a social-ecological systems framework do (e.g. Berkes and Folke, 1998) – but as internally related components (Swyngedouw, 2004). Linton and Budds (2014: 4) describe this concept as follows: "[u]nderstanding things as related internally means that the properties that constitute them emerge as a function of their relations with other things and phenomena. It implies a shift from thinking of relations between things – such as the impact of humans on water quality – to the relations constituting things – such as the cultural, economic and political processes that constitute the particular character of desalinated water, treated drinking water or holy water".

In other words, water is not perceived as a purely natural substance that moves through the hydrological cycle, but as a socio-natural hybrid that consists of such different things as physical characteristics, narratives, and values (Linton, 2010). In the process of making and remaking socio-natural hybrids, things such as rain and ice, pipelines and dams, water rights, human labour, forms of water uses, economic benefits, and ancient legends are interwoven and co-produce different types of water, such as drinking water, spiritual water, and irrigation water (Linton and Budds, 2014).

Each type of water emerges from distinct hydrosocial assemblages (Barnes and Alatout, 2012); accordingly, they all have different 'biographies' (Zug and Graefe, 2014) and different politics (Linton and Budds, 2014). Depending on the assemblages in place, water can become a commodity or a public good, a border or a source of collaboration and regeneration, or a material link between past and present (Barnes and Alatout, 2012; Linton and Budds, 2014; Zug and Graefe, 2014). However, these emerging types of water can have very different meanings for distinct stakeholders.

While political ecologists generally stress the important role of capital accumulation in this process of co-construction (e.g. Swyngedouw, 1996), anthropologists and other social scientists highlight the role of the different meanings water can have for people; how these meanings emerge through people’s material, sensory, and imaginative interactions with water; and how these interactions themselves become encoded in the water (Strang, 2004; Mosse, 2008; Orlove and Caton, 2010). Moreover, scholars such as Zug and Graefe (2014) highlight the importance of supplementing the rather top-down perspectives prevalent in critiques of capitalist relations with a focus on consumers and their everyday practices. Thus, as Linton and Budds (2014: 5) state, "water and people are not just related in a material sense, but are also connected in experiential, cultural and metaphorical ways".

While several scholars have explored water as a socio-natural hybrid (Swyngedouw, 1999; Linton, 2010) and investigated the multiple meanings water can have for people (Strang, 2004), relatively few studies have combined the investigation of hybrid water and of its meanings from different water user groups' perspectives.

However, integrating different stakeholder perspectives is key, as many conflicts over water are related to a lack of knowledge not about systemic interrelationships but about the competing sustainability values of different stakeholders (Miller et al., 2014).

Hybrid waters and sustainability

The concept of water as a socio-natural hybrid offers an interesting approach to water sustainability. It makes it possible to relate biophysical, economic, and social aspects in a novel way that truly considers the complex links and co-evolving processes between these aspects. Moreover, it takes into account ethical and normative aspects in the analysis of water sustainability issues. I assume that the study of water as a socio-natural hybrid will lead to a deeper understanding of how these different aspects, including material conditions, governance, everyday practices, and people's value systems, are interwoven. Moreover, I expect such an analysis to provide insights into the processes and factors that determine whether water sustainability will be achieved. This, in turn, will provide guidance on where best to intervene in order to change the relationships among the many aspects of hybrid water in favour of a more sustainable future.

GOAL AND METHODOLOGICAL FRAMEWORK

This study looks at the case study region of Crans-Montana-Sierre, Switzerland, to explore questions of water sustainability through the concept of water as a socio-natural hybrid, taking into account different stakeholders' perspectives.

The study follows a qualitative research paradigm (Flick, 2005) and consists of two main steps. First, I assessed what sustainability values are important to different water user groups (residents, winegrowers, stock farmers, tourism entrepreneurs, the hydropower plant operator, and an environmental organisation[1]) and analysed what sustainability challenges these water user groups are currently experiencing and anticipate for the future. To accomplish this step, I conducted, together with student collaborators, 79 qualitative interviews with different water users. Moreover, I incorporated insights from a series of ten meetings with a stakeholder group consisting of representatives of the water user groups and communal and cantonal authorities,[2] as well as from participatory observation at events organised by stakeholders. Interviews and stakeholder meetings were recorded and analysed using the audio analysis software Transana.

Second, I analysed what types of water are relevant in the case study region, how they are related to water users' sustainability values, and what kind of hydrosocial processes cause the sustainability challenges. To do so, I iteratively combined and contrasted different sources of knowledge. I started with the water users' discourses about water and the terms they used for distinct types of water (e.g. drinking water, irrigation water, residual water). Subsequently, I analysed the hydrosocial characteristics of these types of water (e.g. their physical qualities, their main meanings, the related infrastructure, and the governance actors and rules involved) as well as the processes that build them. For this analytical step, I conducted a systematic review of existing scientific work about the region's

[1] I consider this environmental organisation to represent nature as a key water user.

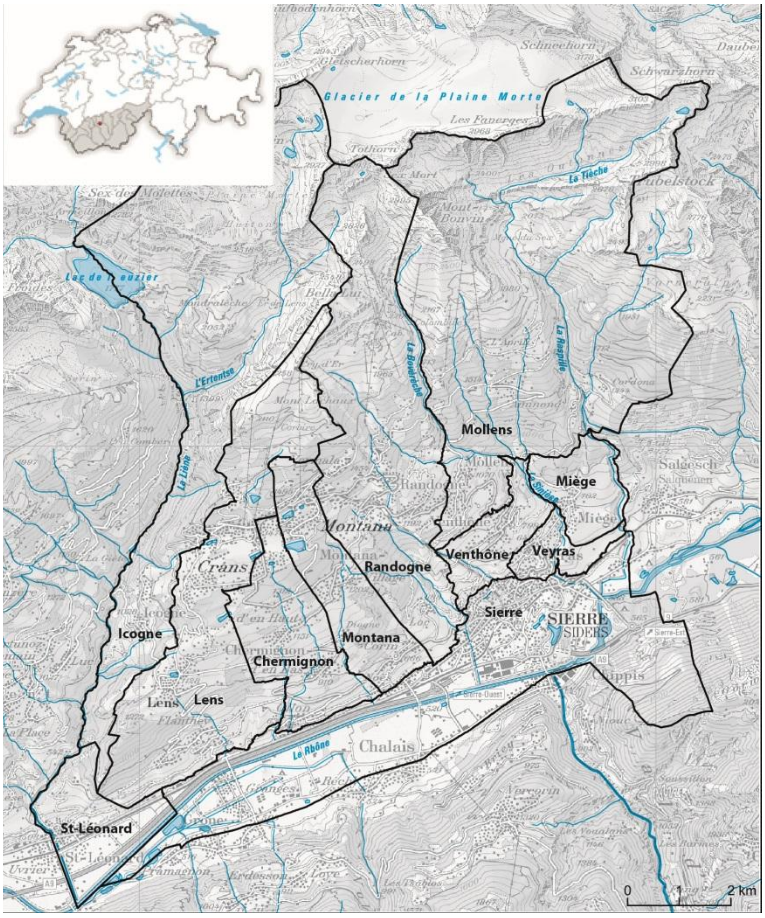
[2] 'Communes' and 'cantons' are the two main subnational administrative levels in Switzerland. Communes are the smallest administrative division, comparable to municipalities elsewhere; cantons are the member states of the Swiss Confederation and the country's largest administrative division.

hydrology (Finger et al., 2013), geology, glaciology (Huss et al., 2013), land use, water use (Reynard and Bonriposi, 2012; Bonriposi, 2013), and decision-making and governance structure (Bréthaut, 2013, Schneider and Homewood, 2013).[3] Moreover, I analysed the water users' daily practices based on the above-mentioned interviews.

CASE STUDY REGION

The case study region of Crans-Montana-Sierre is located on a south-facing slope in the Swiss canton of Valais (Figure 1); it is one of the driest areas in Switzerland (Weingartner and Spreafico, 2010). The region reaches from 500 metres above sea level (masl) in the Rhône River valley bottom to 3000 masl on the Plaine Morte Glacier and has a strong hydrological gradient, with a difference between precipitation and evapotranspiration of about 150 mm/y on the dry slopes. The discharge of meltwater from the Plaine Morte Glacier is an important water resource (Reynard et al., 2014).

Figure 1. The Crans-Montana-Sierre Region and its 11 communes (Schneider and Homewood, 2013).



Politically, the region extends across 11 communes each of which has its own water management body. Land and water use follows a stratified altitudinal pattern (Reynard, 2000), with the region's economic

[3] Many insights about the socio-hydrological cycle were gained through presentations of and discussions with four PhD students (Mariano Bonriposi, Christine Homewood, Martina Kauzlaric, Emmanuel Rey) who have conducted their research in the area (unpublished work).

centre of Sierre (15,000 inhabitants) in the Rhône River valley bottom, several mixed residential and farming villages on the lower slopes (viticulture, livestock production), and the tourist resort of Crans-Montana (skiing, golf, hiking) above 1500 masl. With more than 37,000 tourist beds, Crans-Montana is one of the largest mountain tourist resorts in Switzerland. The largest amount of water by far in the region is used for hydropower production, with the source water stored in an artificial reservoir (Lake Tseuzier).

The region has regularly experienced water scarcity[4] as a result of dynamic socioeconomic developments, the multiplicity of different water uses (drinking water, irrigation, artificial snow production, hydropower, etc), and the highly unequal distribution of water resources (Reynard, 2000; Schneider and Homewood, 2013). Moreover, a recent interdisciplinary study showed that periods of water scarcity might become more frequent in the future and that socioeconomic developments will have a greater impact on the future water balance than will climate change (Reynard et al., 2014).

WATER USERS' SUSTAINABILITY VALUES IN RELATION TO WATER

Overall, the interviewees' discourses about water sustainability can be structured along eight basic values. In the following paragraphs I outline how water users understand these values and what challenges they see today and in the future. An overview of the sustainability values and related challenges is given in Table 1.

Habitat for plants and wildlife

All interviewees stressed the life-giving nature of water. Water is seen as the source of all existence; without water there would be nothing. Correspondingly, most interviewees mention the significance of water for nature, particularly for the survival of plants and wildlife. However, only relatively few interviewees prioritise these aspects in the case of competing uses. They criticise in particular that minimum water flows are not guaranteed in rivers downstream of withdrawal sites (e.g. the hydropower dam). Moreover, they fear that the Raspille River in the east of the region – one of the last rivers in the entire canton without hydropower facilities – could be regulated by means of engineering structures. These interviewees, including representatives of the environmental organisation and the public environmental agencies, consider lacking minimum flows as one of the region's main sustainability challenges.

Source of human life

Water as a fundamental prerequisite of human life is the most uncontested sustainability value mentioned by the interviewees. They consider that always there should be enough water for drinking and other forms of household consumption, as well as for food production.

Residents tend to take water for granted. This reflects the fact that communal water management fully guarantees a drinking water supply. Only a few residents mentioned events where they had been directly affected by issues of physical water shortage, be it low water pressure in their home or discussions in the community about building new water reservoirs. Generally, they believe that the government will solve upcoming problems. This contrasts with statements by interviewees involved in communal water management. Especially those from communes with a few or no drinking water sources expressed considerable concern about how to guarantee a reliable water supply. In recent years, these communes have been able to buy water from other communes, but they worry about what might happen if periods of water scarcity increase due to rising temperatures and population growth.

[4] Water scarcity is understood here as a situation where the demand for water is greater than its supply.

Regarding food production, the interviewed winegrowers reported no major shortages in irrigation water in recent years. Only winegrowers in the valley bottom whose irrigation system is connected to the drinking water system were not allowed to irrigate their grapes in particularly dry years. Winegrowers see their water future as rather positive. They believe that they can easily adapt to rising temperatures by planting other grape varieties or by installing drip irrigation systems.

Stock farmers likewise described relatively few water-related challenges resulting from physical water shortage. For example, they mentioned that in very dry years they are not allowed to irrigate their meadows in summer, especially during the international golf tournament in Crans, when the lakes on the golf court have to be full and picturesque, or during times when the vineyards need large amounts of water. However, stock farmers are much less confident in the future than the winegrowers. They fear that agricultural water will lose priority. They especially fear that the growing population will eventually convert their fields into residential areas and claim the water for other purposes.

Limited financial and social costs

Limited financial and social costs comprise another often-mentioned sustainability value. Different water users we interviewed stressed that, very dry years aside, problems are not caused by a physical lack of water but by the various water-related costs. For example, nearly all stock farmers reported that irrigation meant hard work – also during night hours – and high financial costs, especially in connection with the construction and maintenance of irrigation infrastructure. They also mentioned occasional social conflicts among users of joint irrigation systems. Their concern is thus not so much about regular prices for water – drinking water is rather cheap, and irrigation water is generally free – but about the costs of labour and collaborative efforts. Fewer and fewer young farmers are willing to spend time maintaining traditional irrigation channels.

Representatives of the golf industry as well as communal drinking water managers complained about the large sums they have to pay in dry years to buy water from the hydropower company. They reported paying five to ten times more in dry years than in normal years.

Well-being and recreation

Besides the immediate life-giving nature of water, all interviewees stressed its importance as a source of well-being and recreation. Particularly the glacier, the lakes, and the traditional irrigation channels are among the residents' favourite places in the landscape. These landscape features were also highlighted by tourism entrepreneurs. Traditional irrigation channels seem to play a particularly important role in summer tourism and are an important symbol of water in the region. Trails along these channels are among the best known and enjoy great popularity, especially among elderly hikers and families with children. In the winter season, the tourist industry advertises the availability of snow and the resulting opportunities for skiing and walking through a snow-covered landscape.

Residents and tour operators seemed to be quite satisfied with the current situation. Concern was only expressed with regard to low water levels in the lakes and the reduced appeal this has for tourists.

For the future, however, tour operators in particular anticipated considerable challenges to maintain the water's function as a source of well-being and recreation. They mentioned the melting glacier and the reduced reliability of snow coverage, and expressed fear of losing not only an important tourist activity (skiing) and a symbol of the Valais, but also the important water storage function of ice and snow. As a consequence, they expect increasing conflicts over water extraction for artificial snow production and the irrigation of golf courses. Some mention that this might result in the construction of a new reservoir along the Raspille River; however, this would destroy this valley's pristine character.

Personal and cultural identity

Many aspects mentioned by interviewees referred to the significance of water for their personal and cultural identity. Several interviewees began their narratives about water by referring to their ancestors who invested time and energy in constructing irrigation channels to bring the water to their crops on the hill. Maintaining these traditional channels and the precious mountain water is perceived as part of the important obligation to preserve the ancestral heritage.

Agricultural water use seems to be at least as significant for maintaining key cultural traditions of the Valais as it is for producing food and generating income. A considerable portion of the population owns vineyards, and these people feel strongly attached to their vineyards. Most inherited them from their grandparents, used to work in them as children, and now regularly meet there with friends and family. Breeding Hérens cattle – an old regional cattle breed – is another important cultural tradition. Interestingly, stock farmers do not stress their role as food producers. Indeed, the importance of agriculture in this region is more related to landscape conservation than to intensive food production.

Many residents also expressed their desire to live in a green environment, which in this area requires irrigation. Irrigating agricultural fields means preventing them from becoming a desert.

In recent years, the water's significance for maintaining cultural heritage has increasingly gained recognition. In several cases, irrigation channels that are no longer used for agricultural purposes have been reconstructed for recreational use by tourists and residents.

Economic development of the region

In the context of economic development, many interviewees mentioned touristic water uses, such as golf course irrigation and artificial snow production, as well as hydropower production as important sustainability values. Irrigation of golf courses is considered fundamental because golfers, although relatively few in number, bring considerable income to the region. Artificial snow production is viewed as indispensable for guaranteeing reliable snow conditions for skiers. In these cases, the core value of water lies in attracting tourists and bringing money to the region.

According tourism entrepreneurs, future challenges include increasing water competition due to global warming – increasingly unstable snow conditions result in higher demands for artificial snow – and population growth. In contrast, the hydropower company is quite confident, as research has shown that glacier melt will increase the amount of water available to them until 2060 (Huss et al., 2013). However, they face uncertainty due to ongoing developments in the international energy market as well as upcoming negotiations regarding renewal of their water concession, which will run out in 2037.

Responsible use

Many interviewees expressed great pride in their water, saying they feel privileged to have such exceptional and pure mountain water. Accordingly, many also mentioned that they consider responsible use of water and the avoidance of wastage to be an ethical obligation. This opinion was voiced independently of whether or not interviewees believed that water is in short supply. Expressions of the obligation to use water responsibly included rejection of what was deemed luxury uses – such as private pools and irrigation of private lawns and golf courses – as well as wastage through inefficient irrigation practices or careless use in the household. Artificial snow production was also highly contested. Many interviewees, even tourism entrepreneurs, considered these touristic uses as morally problematic ('luxury uses', 'ecological damage') and described them as a 'necessary evil' to advance the region's economic development.

Equity

Equity issues were expressed by different interviewees, but most prominently by representatives of water-poor communes, who criticised the unequal distribution of water rights. They perceive it as unjust that water rights are generally restricted to those communes whose territories include water bodies or springs. Other interviewees complained that the above-mentioned luxury uses benefit only a few, which runs counter to their ethical values, and that these uses compete with more fundamental ones. For example, they criticised the fact that farmers are requested to limit irrigation while tourists can continue to waste water.

SUSTAINABILITY AND DIFFERENT TYPES OF WATER

When speaking about water sustainability, people used the term 'water' for many different types of water. Sometimes they used specific terms, such as 'irrigation water'; sometimes they just highlighted specific elements, meanings, and constitutive processes. Overall, the analysis revealed that each identified sustainability value is related more strongly to some types of water than to others (for an overview see Table 1).

Table 1. Water users' sustainability values, related sustainability challenges, and types of water.

Water-related sustainability values	Related current and future sustainability challenges	Types of water representing sustainability values
Habitat for plants and wildlife	Lack of minimum flows, loss of dry meadows	Residual water, irrigation water
Source of human life	Unreliable water supply, unequal distribution of water rights, lack of water for irrigation	Drinking water, irrigation water
Limited financial and social costs	Building and maintenance of infrastructure, labour, collaboration, conflicts, high prices	Different types
Personal and cultural identity	Melting of glacier, maintenance of traditional irrigation channels	Irrigation water, recreational water
Well-being and recreation	Low lake levels, unreliable snow conditions, regulative structures in wild rivers and streams	Recreational water, irrigation water
Economic development of the region	Water competition, ethical issues	Economic water, recreational water
Responsible use	Wastage of water for luxury uses, use of drinking water for irrigation	Different types
Equity	Unequal distribution of water rights, luxury uses, process of priority setting	Different types

Five distinct types of water emerged from the analysis that seems to be particularly relevant for exploring sustainability issues: irrigation water, drinking water, recreational water, economic water, and residual water (Table 2). These types of water are characterised by distinct hydrosocial assemblages with regard to their uses, source, and quality, as well as related infrastructure, governance actors, legal

Table 2: Overview of five types of water and their main hydrosocial assemblages.

Elements of hydrosocial assemblages	Types of water				
	Irrigation water	Drinking water	Recreational water	Economic water	Residual water
Main components	Water that is not treated and is governed by ancient water rights	Treated water that is safe for drinking	Landscape water that can be experienced directly (lakes, traditional irrigation channels, rivers, waterfalls, snow, glacier)	Water that generates economic value	Water that is indispensable for certain ecological purposes
Main uses	Agricultural irrigation	Household consumption, wine production, irrigation	Recreation and enjoyment	Golf course irrigation, artificial snow production, hydropower	Preservation of habitats, replenishment of aquifers
Source	Glacier, irrigation channels	Springs	Various	Irrigation water, hydropower dam	Dams
Quality	Untreated	Treated (potable)	High aesthetic quality	Untreated	Untreated
Infrastructure	Traditional irrigation channels, irrigation systems	Pipelines, treatment plants	Channels, dams	Dams, turbines, snow guns, irrigation systems	Withdrawal sites, e.g. dams
Governance actors	Traditional water associations, communes	Individual communes	Variable	Private companies, communes	National and cantonal government
Main legal basis	Ancient water rights	Cantonal and communal law, contracts	Various	Contracts, concessions	National environmental law, concessions
Costs to users	Free, but use of infrastructure has to be paid	Moderate prices, depending on commune	Free	Depending on contract/ concession and source	Free, but generates loss of profits for electricity companies and other users
Main meanings	The water that was brought to the dry slopes by the ancestors Hardship and work Uncontested and life-giving	Pure mountain water Taken for granted Uncontested and life-giving	Natural, clean, fresh, and impressive Spiritual dimension	Water for economic development Contested and sometimes morally questionable	Lost water

rules, costs, and meanings. However, the boundaries between them are not sharp but blurred, and they may overlap.[5] The five types of water are discussed below; Table 2 provides an overview.

Irrigation water

When people speak about 'irrigation water' (*l'eau d'irrigation*) they mainly mean water that originates in the water-rich high mountain areas (especially the glacier), has the physical quality of water naturally flowing in rivers, traditional irrigation channels, and lakes, and is governed by traditional water associations (*consortages*) and ancient water rights (*droits d'eau*). The water associations collectively organised the construction and maintenance of irrigation channels, and they established rules on water distribution. Some of these ancient rights date back to the 12th century. Irrigation water is generally free, but at the same time connotations of hardship and collective work are also a fundamental part of it. Without these components, irrigation water would scarcely exist on the lower slopes, where the difference between precipitation and evapotranspiration is only about 150 mm/y.

As irrigation water is used by winegrowers and stock farmers to irrigate their fields and by tourism entrepreneurs to irrigate golf courses and produce artificial snow, this type of water contributes – through its use – to the values of sustaining human life and of advancing economic development in the region. Whether or not these values can be achieved by means of irrigation water strongly depends on precipitation patterns, the specific water rights situation, and the various users' negotiation power. Winegrowers seem to have a stronger position than stock farmers. On the one hand, winegrowers need irrigation water mostly during the flowering season in early summer, when there is still enough water available, whereas stock farmers need it also in late summer when it becomes scarcer. On the other hand, winegrowers are organised in traditional water associations who are responsible for most irrigation practices (including infrastructural work) and also defend their members' interests, while most stock farmers act independently. Interestingly, ancient water rights that usually apply to irrigation water play no role for individual stock farmers. In fact, these rights only seem to become relevant when it comes to water distribution between the communes. This means that in normal years, stock farmers have free access to water and can irrigate as much as and whenever they want; but in dry years, during times of shortage, communes may limit the use of irrigation water, for example reserving it for wine production, or treating it for use as drinking water. In these situations, drinking water and economic performance are clearly prioritised.[6]

However, the hydrosocial processes constructing irrigation water are relevant for achieving most other sustainability values too, even if its use as such is not as important. In the case of personal and cultural identity, for example, it is above all the collective memories and stories attached to irrigation water and the existence of certain constituting elements such as traditional irrigation channels that play a major role. The memories are about how water has been stored in the glacier in the high mountain areas, and how it has then been transported to the dry areas on the slopes through traditional irrigation channels that were built by heroic ancestors. These collective memories are strongly symbolised by the traditional irrigation channels. Recognising this fact, local communities have invested heavily in reconstructing these channels and keeping the collective memory alive (e.g. by building a museum about the channels and their history).

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[5] Any typology is to some degree deliberate. Depending on place and time, each type of water has a (slightly) different biography and is perceived (slightly) differently by different people. Thus, the boundaries between types could have been drawn along other hydrosocial assemblages (e.g. aesthetic water could have been distinguished from other types of recreational water). Ultimately there are at least as many types of water as there are water users.

[6] Given that irrigation water has very different and distinct meanings for winegrowers and stock farmers and even involves distinct sets of governance actors, it might be described as two distinct types of water. I chose not to do so because the term 'irrigation water' is very strongly rooted in the case study region.

Drinking water

The term 'drinking water' (*eau potable*) is used by interviewees whenever they speak about tap water. This water has been treated before distribution to households to assure its quality (e.g. using filters and ozone) (Bonriposi, 2013). In the past, drinking water originated primarily from springs in the high mountain areas, but today it is also produced from irrigation water (Bonriposi, 2013).[7] Drinking water is used for various domestic and commercial purposes, including drinking and cooking, hygiene, irrigation of gardens and parks, and washing cars. In some communes it is also used for agricultural irrigation (Reynard et al., 2014).

Hydrosocial processes related to drinking water are most relevant for achieving the sustainability values of sustained human life, limited costs, responsible use, and equity. The relation of drinking water to these sustainability values can be illustrated using the example of reliable drinking water supply. While irrigation water is mostly governed by traditional, transcommunal water associations and ancient water rights, drinking water is governed by the individual communes, written law, and formal and informal agreements (Bonriposi, 2013; Reynard et al., 2014). According to current national and cantonal laws, the communes have the right to decide about the use of public water bodies within their boundaries. However, water bodies – including springs – and their discharge intensity are very unequally distributed among the different communes. While some communes own additional springs on the territory of other communes (e.g. in cases where a commune was split up in the past), others largely depend on negotiated long-term, but mostly ad-hoc, water use agreements and purchases from other communes. Consequently, some communes have access to disproportionately large amounts of water: one commune with only several hundred inhabitants owns the largest share of the regions' water resources. At the same time, other communes do not have enough water to cover their needs (Schneider and Homewood, 2013). The latter have to buy water from the former, and are therefore highly dependent on the former's cooperation.

Recreational water

Recreational water was often the first type of water mentioned by interviewees, be it residents, tourism entrepreneurs, or farmers (although they rarely called it that). When speaking of this water they referred to various physical forms of water ranging from rivers, waterfalls, water channels, natural and artificial lakes, and reservoirs to rain, snow, and ice. The common characteristic of this water is that it is visible in the landscape and can be experienced directly. It can be enjoyed by relaxing in its vicinity (e.g. lakes), gazing from a distance at the impressive forms it takes (e.g. waterfalls and glaciers), strolling through it (e.g. snow-covered landscapes), hiking along it (e.g. traditional irrigation channels), and playing with or in it.

Recreational water is most relevant for the sustainability values of well-being and recreation, personal and cultural identity, and economic development. For example, snow-covered landscapes, lakes, and hikes along traditional irrigation channels are important not only to residents, but also to tourists, and consequently they are relevant to the region's economic development. While some forms of this water are primarily created through natural processes (e.g. ice and snow), others include man-made structures such as dams and channels. The governance processes involved are diverse; what counts is the outcomes regarding the water's aesthetic quality, its embeddedness in the landscape, and its potential for recreation and enjoyment. Challenges emerge when this water is missing (due to extraction or a lack of precipitation) or its aesthetic quality is harmed (e.g. low lake levels, lack of snow in winter, empty traditional irrigation channels).

[7] However, the idea that drinking water is spring water is very deeply rooted in residents, tourism entrepreneurs, and even water technicians.

Economic water

Interviewees often stressed the strong link between water and the economy, and that some water is especially strongly governed by economic rules. I refer to this type of water as 'economic water'. While economic benefits can be generated from most types of water (e.g. irrigation water for wine production), I use the term 'economic water' for water that (a) has a particularly high economic value or (b) is used for activities that are justified by their high economic value (e.g. artificial snow production and irrigation of golf courses). Private, profit-oriented companies have an important stake in the governance of this water.

Economic water is particularly relevant for the sustainability values of economic development, equity, and responsible use. Water under a hydropower concession is the main example. The water-rich communes granted the hydropower company a concession in 1957 which allows the company to use all water that flows into the reservoir, with the exception of a certain amount which it has to supply to farmers, who are the original water-right holders. The water the company can use corresponds to about half of the water available to the whole region (Reynard et al., 2013). In exchange for granting the concession, the conceding communes receive water rates. In this way, the use of this water contributes to economic development in these communes.

However, when other water users and communes need to buy stored water from the hydropower company in times of scarcity, they have to compensate the company for the loss of profits, meaning that they have to pay the price that the company could obtain by producing hydroelectricity. Thus, while the hydropower dam makes it possible to store water for drier periods and thereby contributing to several other sustainability values, considerable challenges need to be overcome before the values of equity and limited costs for other users can be achieved.

Residual water

The term 'residual water' is used by interviewees for water that has to remain in a watercourse downstream of a withdrawal site. The amount of residual water has been regulated by national law (Swiss Water Protection Act) since 1992. The respective legal regulations were enacted as a result of increasing water withdrawals, especially by hydropower companies, and respective environmental concerns. The minimum flows defined by the law are intended to preserve habitats for plants and wildlife, form a landscape element, feed aquifers, and break down pollutants.

However, the concerns expressed by interviewees showed that minimum flows are often lacking, with negative effects on aquatic plants and wildlife. Many water users, such as hydropower companies, perceive residual water as lost water. The regulations apply only to water withdrawals that were initiated after 1992 or are subject to a water use concession that has been renewed after that date, and the canton has so far refrained from implementing transitory measures. Accordingly, in many cases availability of this type of water is not guaranteed.

Despite its physical absence, residual water clearly exists in the minds of the interviewees – as a promise of better ecological conditions for some, and as a threat of a future competing water use for others. Indeed, a recent scientific study (Reynard et al., 2014) showed that the amount of residual water required by law will determine whether there will be enough water to satisfy other sustainability values in the future.

UNDERSTANDING SUSTAINABILITY CHALLENGES THROUGH DIFFERENT TYPES OF WATER

In the previous section I described different types of water and gave examples illustrating their relations to the various sustainability values and challenges. As each sustainability value is related more strongly to some types of water than to others, and these different types of water are constructed by different hydrosocial assemblages (including different actors and legal rules), several sustainability challenges can be better understood by focusing on one particular type of water.

In most cases, however, the sustainability challenges can only be fully understood if the interplay between different types of water is taken into account. Four processes proved to be particularly important in this regard.

Blending

In some cases, different types of water are not spatially exclusive, but blend with each other. This is particularly the case with recreational water. A body of water, for example a lake in a golf course, can be composed of recreational water, economic water, and irrigation water. Withdrawal of irrigation water from such a lake contributes to food production and, thus, to the sustainability value of sustaining human life; but at the same time it diminishes recreational water by lowering the lake level, which in turn diminishes the sustainability values of well-being and recreation as well as economic development through tourism. Conversely, not allowing farmers to irrigate their fields diminishes the value of food production while maintaining the aesthetic quality of the lake.

In this way, processes linked to one type of water can cause the sustainability challenges associated with another type of water. To understand the challenge of an irrigation water shortage we have to include recreational and economic water and power relationships between the different governance systems in our analysis. In the above case, the fact that recreational water is at the same time economic water might explain its prioritisation over its use as irrigation water. The well-being of golfers is considered more important because golfers bring considerable income to the region, whereas stock farming is of minor economic significance.

Transformation

The analysis also showed that one type of water can be transformed into another type of water. This transformation process can solve some sustainability challenges, but it can also produce them. For example, economic water such as the water owned by the hydropower company can be transformed into drinking water or irrigation water in times of water shortage. This helps to guarantee a reliable supply of drinking water, but it also produces high costs for users in need of water, which in turn raises questions of equity between different water users and communes.

However, sustainability challenges can also emerge when water cannot be transformed. For example, the availability of residual water as habitat for plants and wildlife requires that another type of water – economic water in the case of our case study region – is transformed into residual water. To fully understand why this transformation does not occur, processes related to economic water have to be considered as well. These include, for example, the interests of the communes and the canton receiving taxes from the hydropower company, and the company's position of power.

Incoherence between type of water and its use

Other sustainability challenges are related to incoherencies between the type of water used and the requirements of the use. For example, some winegrowers have to use drinking water to irrigate their fields. But the availability, the price, and the governance of drinking water are different from those of irrigation water. This leads to a situation, for example, where winegrowers who have to use drinking water have to pay more for the same amount of water than those using irrigation water, and in the event of a drinking water shortage they are not allowed to irrigate their grapes while neighbouring winegrowers who have access to irrigation water might be able to continue irrigation. Such a situation leads to challenges regarding the sustainability values not only of limited costs, but also of responsible use: several interviewees criticised the use of treated drinking water for irrigation.

Motivation for behavioural changes

Last but not least, the type of water available can have different effects on water users' motivation to change their behaviour to a more sustainable one. For example, winegrowers who use drinking water are much more willing to invest in water-saving technologies such as drip irrigation systems. Drinking water is viewed as a type of water that should be saved because it is of better quality and more expensive, whereas irrigation water is perceived as abundant and cheap.

CONCLUSION

In this article I explored issues of water sustainability by empirically investigating water users' sustainability values, as well as different types of water and their significance for achieving sustainability.

The analysis of water users' discourses revealed eight sustainability values. Some of these values refer to the physical availability of water (e.g. water as a habitat for plants and wildlife, or as a source of well-being and recreation); others refer to governance practices (e.g. equity, limited costs); and yet others refer to inherent meanings (e.g. cultural identity, responsible use). Analysing sustainability challenges through the lens of different types of water aided consideration of these distinct hydrosocial aspects of water sustainability.

Moreover, the analysis showed that understanding the hydrosocial processes that constitute the different types of water is crucial, but not sufficient to understand sustainability challenges. The interplay between different types of water needs to be considered as well – in particular processes of transformation, blending, and coherence. This very interplay determines whether or not a region's development is advancing towards greater sustainability.

Previous research suggests that focusing on different types of water and the processes that form them provides an entry point for changing these processes (Linton and Budds, 2014). The present analysis partly confirms this finding.

The strong evidence of distinct types of water emerging from distinct hydrosocial assemblages, including largely separate governance arrangements, can be seen as an important entry point for finding solutions to sustainability challenges. For example, although these challenges are often caused by the interplay between different types of water, thus far no water association in the case study region looks at the governance of different types of water from a holistic perspective, taking into account the whole set of sustainability values. Yet such a holistic perspective is key when it comes to tackling sustainable water governance in the case study region.

By focusing on relational processes and individual water users' perspectives, limited knowledge was gained regarding a) what more sustainable water futures would look like, and b) how current unsustainable practices can be effectively transformed into more sustainable ones.

a) Sustainability values: The study confirmed that different user groups have quite different and sometimes conflicting visions for the future; for example, while some emphasise the preservation of aquatic habitats, others prioritise extractions for hydropower production and economic purposes. It also became evident that in many cases there are trade-offs between sustainability values. While one value is improved, another is diminished. Thus, while the identification of water users' sustainability values helps to understand certain conflicts, it does not directly contribute to a general definition of what a more sustainable water future would look like.

b) Transformation of knowledge: By tracing the relational processes that have built the current water configurations, insights were gained into how the parts are related. For example, the interviews revealed that the current distribution of water rights, which is mainly a result of historical processes, leads to inequitable access to water for the different communes. This suggests that water rights should be renegotiated based on the needs of people living today. But how this might be successfully achieved – especially in light of the water-rich communes' unwillingness to even enter a dialogue – is still open to investigation and discussion. In other words, the analysis can show quite clearly how the current unsustainable situation came about, but not directly how it can be solved.

Based on these findings, I argue that focusing on water as a socio-natural hybrid while taking into account various water user groups' sustainability values provides a valuable starting point for investigating the complex relationships between material, social, and ethical aspects of water. However, future research must complement this with insights gained from novel approaches that understand research as a part of a deliberative and reflective process of co-production and social learning between all actor groups involved (Rist et al., 2007; Schneider and Rist, 2013). Understanding relational processes, including different stakeholders' sustainability values, is not enough; what is needed are approaches that allow all actors involved to develop a joint understanding of water-related problems and potential solutions, to create joint sustainability visions, and to explore options of transformative change (Wiek et al., 2012; Schneider and Rist, 2013; Miller et al., 2014).

While scholars have been increasingly experimenting with such approaches, theoretically and empirically rich research pathways that incorporate these requirements have yet to be fully realised (Miller et al., 2014). This is particularly true of many studies applying the lens of critical political ecology, including the one presented here. While they provide highly valuable insights, for example, into the political nature of water and the related power relationships, they need to go a step further: they should contribute to society's ability to envision a more desirable future and to transform those power structures in order to achieve the desired future.

ACKNOWLEDGEMENTS

I would like to thank the Swiss National Science Foundation for funding the MontanAqua research project (4061-40-125964/1) within the National Research Program 'Sustainable Water Management' (NRP 61). My thanks also to all students that contributed to the study by conducting interviews, namely Corinne Buff, Esther Kobel, Stephanie Lehmann, and Ariane Müller. A special thank you goes to Christine Homewood who influenced my argumentation through discussing insights from her PhD research. Moreover, I also would like to acknowledge support received by the Decision Center for a Desert City II: Urban Climate Adaptation, funded by the US National Science Foundation under Grant SES-0951366. I also express my gratitude to Sally Wittlinger and Marlène Thibault for editorial assistance.

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