# Chapter 10
# Governance in the Face of Uncertainty and Change

**Abstract** This chapter presents the first stage of findings in the multi-pronged approach, used to triangulate towards a more nuanced and empirically based set of adaptive capacity indicators. First, the results from the assessment and categorization of the adaptive responses are presented, elucidating the adaptive mechanisms across the different governance scales. Next, those mechanisms are characterised according to the categories of transformation, persistent adaptation and passive responses. Finally, the different categories of adaptive outcomes are discussed in more depth in relation to the specific governance mechanisms associated with them. Results indicate a higher concentration of transformative and persistent adaptive responses in the Swiss case area than in the Chilean case area.

**Keywords** Rhône, Canton Valais, Switzerland • Aconcagua, Region V, Chile • Assessing adaptive mechanisms • Adaptive outcomes • Transformative adaptation • Persistent adaptation • Passive change • Governance scales

## 10.1 Adaptive Mechanisms Across Scales

The following section and table records the different institutional and governance mechanisms that were mobilised, drawn on, or relevant to preparing for or navigate the case events in each case area. The different mechanisms recorded in Tables 10.1 and 10.2, are categorised by the different scales in which they are invoked. For the purposes of this study, adaptive mechanisms are termed as a response, institutional or governance mechanism (law, regulation, policy, institution) that are undertaken at the national, regional or local (both community and individual) level in order to prepare for or respond to different scales of environmental change (i.e. inter-annual variability, drought, floods, climate change impacts).

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**Table 10.1** Overview of adaptive actions and major institutions, governance and management mechanisms affecting adaptive capacity identified in the Chilean case

| Case area | Scale | Institution/governance mechanism/adaptive action | Explanation/example |
|---|---|---|---|
| Aconcagua basin, Chile | National | Presidential Declaration of Drought Zones (Water Code, Art. 314)<br>Provides for the declaration of a drought zone for a maximum of 6 months, allows the General Directorate of Water (DGA) to intervene on request in the management of the river and redistribute the water (as in 1996), allows the extraction of superficial or subterranean waters where users do not have rights, prioritises human consumption of water (but liable to pay compensation to users adversely affected by decisions during drought situations). | Article 314 (Water Code) allows prioritisation of uses in a river basin, for the construction of hydraulic engineering works to abstract water without water rights, for the potential intervention of the DGA to manage water distribution, as well as for the prioritisation of water uses, namely for drinking water and agriculture. The declaration aims to mitigate harmful effects of drought partly by reducing the amount of irrigation, as opposed to suspending it altogether, allowing farmers to reduce the losses of their crops at least partially. However, in allowing the abstraction of water for which users do not have rights, the DGA is liable to pay compensation to rights holders whose water rights are affected by the increased extraction of groundwater. |
| | | Resolution 39 (1984)<br>Resolution establishes the 3 criteria for the DGA regional office to call a period of drought. The resolutions refers to Regions I, II, III, IV, V, metropolitan and VI. The three parameters are set as follows, and require that:<br>(1) Stored/accumulated rainfall, as from April is less than 70% of the average statistical value; within the same point<br>(2) Accumulated rainfall as from September should have a return period of 10 years<br>(3) Monthly average flow of rivers is less than 70% from the average statistical flow of the that same month. | These three parameters are the criteria set to declare a drought event in Region V. The resolution dates back to 1984, and has not been updated since. The regional DGA office is unclear as to whether the hydrological scarcity decree can be issued based on 1 or the 3 criteria. Additionally, the hydrological parameters have remained consistent with 1984 hydrological records. |

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| Commision Nacional del Riego (National Commission for Irrigation) – Law on Promoting Irrigation Efficiency (Ley 14.450)<br>Law 14.450 had provided financing and subsidies to farmers to improve irrigation efficiency. The CNR was responsible for implementation of the law, and managing the legal instruments that funded projects aimed at increasing agricultural output as well as efficiency. | Law 14.450 had focussed mainly on increasing agricultural output, but ended in 2010. It was renewed with an updated focus, in that farmers must now focus on water efficiency in their new projects. Within the submission criteria for projects, different points are allocated for different criteria, water efficiency being one of them. Promoting efficiency is one of the main lines of intervention with farmers for the CNR. |
| Direcion General de Aguas/General Directorate of Water<br>The DGA is responsible for the allocation of water, the monitoring of water quantity in surface and groundwater, and the maintaining of sustainable levels of abstraction according to a set of internal directives. | Major focus at the moment is to improve the transparency, availability and quality of the water rights information system (Cadaster de Agua Publica). |
| Direcion de Obras Hidrologicas/Ministerio de Obras Publicas<br>The General Directorate of Public Works and Directorate of Hydraulic Works coordinate plans and proposals on water infrastructural works that aim to increase efficiency and improve irrigation security in response to increasing water losses and drought events. | Los Aromos Dam is situated in Section 3 of the basin at Limache, with a volume of 35 million $m^3$. As the government body responsible for the construction of major water infrastucture, the DOH is the main istitutional partner for the Aconcagua Project. |
| Aconcagua Project<br>Major infrastructural project to improve irrigation security in Region V. | The Aconcagua Project was first officially presented in 2001, with the purpose of constructing a dam at Puntilla del Viento, along with two other dams, and a battery of wells that would recharge from the dam in order to improve the irrigation security and allow for water transfers to La Ligua. For a more detailed discussion of the project refer to Box 10.4 in Sect. 10.2.3. |

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**Table 10.1** (continued)

| Case area | Scale | Institution/governance mechanism/adaptive action | Explanation/example |
|---|---|---|---|
| | Basin | Mesa Technica de Aconcagua<br>Regional round table for interested stakeholders for the Aconcagua Project. | Informal group of stakeholders in the basin, mainly agricultural actors, that is lobbying for the construction of the Aconcagua Project. The group consists of hydrologists, farmers, representatives from the DOH, as well as CODELCO and COLBUN. |
| | | Turno between Sections<br>The turno is the process employed during drought periods to manage a proportional reduction of water rights and distribution of water to different users on a specific daily schedule. | The system is a management mechanisms to reduce the amount of water each rights holder receives, while attempting to ensure that all the rights holders do receive a proportion of their water rights. The turno is divided into shifts, which last a certain number of days. Turno occur between for example, if there are five zones to a canal, each zone will receive water for 7 days. So the first zone is allocated water for 1 week, and then the next 4 weeks they receive no water. During the time that it doesn't receive water, the zone is dry, and the other zones are allocated water in their shifts. |
| | Local | Junta de Vigilancia (Vigilance Committee) and comprising Association de Canalistas (Canal Association)<br>These user based associations manage water allocation within and between sections of the river according to property rights and availability. They are responsible for coordinating proportional reduction amongst the members of the junta or canal association based on daily monitoring of the level of river flow. | Private negotiation is common between user associations across different sections of the river, and amongst the different sectoral actors (agriculture & water supply). The managers of the Juntas negotiate with the DGA to intervener not intervene in the management of the basin. |

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|---|---|
| The turno is the process employed during drought periods to manage a proportional reduction of water rights and distribution of water to different users on a specific daily schedule. | receive water for 7 days. So the first zone is allocated water for 1 week, and then for the next 4 weeks they receive no water. During the time that it doesn't receive water, the zone is dry, and the other zones are allocated water in their shifts. |
| Farm/Company level adaptations | |
| Crop Choice – At the farm level, some of the Juntas encourage diversification of crops during more extreme periods. Once planted, the avocado trees are permanent features of the agricultural landscape and have a larger requirement for irrigation. About 70% trees are avocado, the rest are orange, lemons and mandarins. A smaller percentage of farmers grow vegetables, which are much more flexible. | One method is to warn farmers in advance of the planting season, that the next summer is likely to be dry allowing them to not plant certain vegetable and plants and so reducing their overall demand for water. |
| Extraction of underground water, for which farmers may or may not have rights. | Farmers also adapt to the reduction in supply (from the turno or not) by relying on wells used to extract underground water (whether or not they have rights to it). Therefore, when surface water dries, they can just dig down to extract the groundwater. |
| Water Transfers from Aconcagua River to drier areas of the region. | Water transfers have been conducted between the Aconcagua River to La Ligua, Limache and Marga-Marga using trucks to transport the water across during drought periods. |

**Table 10.2** Overview of adaptive actions and major institutions, governance and management mechanisms affecting adaptive capacity identified in the Swiss case

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| Rhône basin, Canton Valais Switzerland | Federal | 1992 Federal Water Protection Act (WPA, Art 29)<br>Residual flows now quantitatively protect flowing waters; efforts to reduce impacts from hydro-peaking; legislative guidance on sustainable management of water resources | The updated water law passed in 1992 provides for the enhancement of ecological services and the sustainability of waterways. It led to new policy guidance on flood management, that has been implemented in the plan for the TRC. However, there are no overarching principles on managing water conflict or stress. |
| | | Bundesverordnung für Trinkwasserversorgung in Notzeiten/ Federal Ordinance on Drinking Water Provision in Emergency Periods (1995)<br>The Federal Government proposes an organisational structure to deal with drinking water in any kind of crisis, i.e. drought, earthquakes, war, floods. It is an ordinance of the WPA. | This has yet to be implemented in the Canton Valais. The canton is supposed to develop a 'wasserkarte/atlas' (a water map), which is a separate requirement to the hazard maps, but the Valais has not done this yet. The ordinance provides guidelines as to how to maintain water provision during disaster periods, but does not set guidelines as to priorities during drought periods. |
| | | Wasser Agenda 21(WA21)<br>Informal cross sector collaborative body on water issues in Switzerland with multiple committees | This informal institution represents a cross-sector collaboration that aims to provide guidance and support for adapting to the increasing stresses facing water resources management in Switzerland. |

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| | NFA – Subsidies | |
| | Subsidies are linked to the implementation of federal legislative principles (environmental and participative provisions) through the Neugestaltung des Finanzausgleich (Reorganisation of Financial Equalisation/Compensation between the federal and cantonal governments) | Communes can receive greater subsidies for projects from federal and cantonal funds if they meet certain criteria: Participative planning (2%), Integrated Risk Management (4%), Ecological Aspects (2%) and Technical Aspects (2%). A building or river works project for example could request higher funding if the communes show that the project was planned in a participative manner and that ecological improvements have been made over 5 years. |
| Regional (Cantonal) | Cantonal Law on Utilisation of Hydropower (Art 42)<br>Legal provision for irrigation rights to take priority over residual flows and hydropower concessions from 1 April–30 September | Art. 42 On the Use of Irrigation Canals:<br>The diversion of irrigation water through water canals and conduits that belong to the 'Geteilschaften' or 'Grundeigentümern' rights remain reserved. Where the particular use or concession does not stipulate otherwise, these diversions (i.e. non irrigation) are restricted between 1 April and 30 September. |
| | Third Rhône Correction (TRC)<br>169CHF million project to reinforce flood security in the Rhône valley, with a number of sub-objectives to enhance social, ecological and economic security and well-being. | New integrative and uncertainty based approach to flood management, increased space for the Rhône, emergency evacuation channels, linked to spacial planning. |

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| | MINERVE<br>The project stands for 'Modélisation des Intempéries de Nature Extrême, des Retenues Valaisannes et de leurs Effets' which is the initiative by the canton to improve the modelling of extreme events and natural hazards, their retention and effects. The project represents a public – private partnership between the Canton Valais, l'Ecole Polytechnique Fédérale de Lausanne (EPFL), Météosuisse, as well as a selection of hydropower companies. | EPFL and Météosuisse were engaged in order to develop the information management system, while the hydropower operators have been in negotiations with the canton to secure extra storage in hydropower reservoirs as a means of limiting the impact of flooding events and other natural hazards. At the prior knowledge of a heavy precipitation event, hydropower companies are warned so that the reservoirs (Speicherbäche) can be automatically lowered to buffer the volume of precipitation that comes down. |
| | Cantonal subsidies and support<br>Investment in infrastructure and irrigation technology by the cantonal authority for agriculture (Amt für Strukturverbesserungen, Dienstelle für Landwirtschaft).<br>Modeling and observation networks: Canton authorities are responsible for monitoring and evaluation networks in the Valais, but are vertically connected to MétéoSuisse as well as to the communes and hydropower companies to coordinate information exchange prior to and during extreme events. | The cantonal office for agriculture is encouraging regional farmers to move irrigation technology towards drop irrigation, to enable a 30–40% reduction in water use. Shifts in technology in the vineyards (where drop irrigation is increasingly used) has already reduced water use.<br>Multi-stakeholder working groups supported through cantonal authorities and national level agencies and associations (WA21, Cantonal Agricultural Centre, Association of Utilities) to initiate scoping exercises on climate change impacts in the Valais. Integration of climate information into planning by hydropower companies but general apathy to future impacts in other sectors |

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| | Hazard Mapping<br>Canton authority for river course management (DFSB) provide support, financial incentives and expertise to the communes so that the canton's hazard mapping exercise can be completed. | DFSB are responsible for coordinating the communes and the engineering offices in the production of these hazard maps, and underwriting their validity and publishing them (Art. 3 (1)) since the results of hazard mapping must be transposed into spatial plans (according to FPA). The local authorities are responsible for completing the mapping exercise and implementing its findings. |
| | Cellule scientifique de crise (CERISE)<br>The scientific cell for crises is composed of representatives from the cantonal office for forests and landscape, the DFSB/SRCE and the service for hydropower (service des forces hydrauliques – SFH) in order to aid the authorities in their decision making ability during flood and avalanche hazards. Communes are legally required to ensure the safety requirements, and the canton natural hazards division subsidises their work. | CERISE is split into summer and winter competencies and comprises canton geologists, river work engineers and the natural hazards division and is linked to MeteoSchweiz. Of the 23 regions in the Valais, so far, there are 3 regions where the process already functions. In heavy precipitation events, they need to measure the rainfall quantity in certain streams, but up until now, they have not done this.<br>(http://www.vs.ch/Navig/navig.asp?MenuID=2410&Language=fr) |

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| | Local (Commune) | Municipal Provisions for use prioritisation<br>Ad hoc municipal level directives for reducing water use in periods of drought.<br>Municipal provisions prioritise historic flow rights to agricultural users as per the Law on the Use of Hydropower, Art. 42 (see above).<br>Local agreements for use transference and priority setting (informal Bewilligung). Commune regulations (reglemente) determine when the utilities are able to decide to supply farmers with domestic water. While the priority is the population, when there is 'superfluous' water, farmers are able to be supplied during these dry periods. | The communes are responsible for prioritising the use of drinking water. In Visp and Les Bagnes directives were issued to stop non-essential domestic uses during 2003 heat wave. Fully sometimes impose restrictions (e.g. 1 day per week) during periods of water stress, when precipitation has been low, and run off is reduced.<br>In extremely dry summers, water suppliers have supplied drinking water to the farmers through the fire hydrants as a temporary measure. The utilities may grant, when there is enough supply for the population, an informal authorisation or licence (Bewilligung) that allows farmers to use domestic supply for irrigation between 18.00 and 08.00 (e.g. in Zermatt, this has happened about every 4–5 years).<br>In the high ski resorts, the ski piste operators have agreements with different hydro-power operators to supply water for the snow cannons. In Zermatt, the commune water supplier has supplied water (spring water) for snow making from the end of October to December, but this amount only stands at about 5% currently. In Verbier, the commune utility (Les Bagnes – SIB) supplies water for snow-making from the Lac de Louvie only during the period of October/November. |

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| | Infrastructural Diversification & Integration<br>Development of artificial lakes at higher altitudes to transport water down to villages during periods of high demand and manage scarcity areas. In addition, a number of 'Bergbahnen' have now also constructed their own large storage reservoirs (Speicherbecker), to be able to supply their own needs for artificial snow production, no longer needing drinking water for this purpose.<br>Diversified sources: Domestic use comes mainly from aquifers, groundwater and springs, while hydropower use relies on glacier and snow melt, as do farmers, either from the irrigation canals or pumping from the rivers to supply the fields and meadows. | Currently, the utility in Zermatt can supply water for snow production between mid October to end of December as that is the time when there is sufficient water availability. After mid-December water needs to be supplied to the growing tourist population. In the preceding 10 years, more investment has been channeled into the construction of extra reservoirs and storage for snow production to avoid reliance on utility water. Examples of this can also be found in Montana, with the construction of Lac de Tseuzier. More and more water is needed for ensuring coverage of increasing numbers of slopes by mid/end of November.<br>Competing uses rely on different sources of the hydrological system, so at present avoid direct competition. However, some farmers do irrigate their fields with water supplied from utilities, but in the 2003 summer drought, swapped from using drinking water to pumping water from the Rhône instead. In certain communes, there are measures to reduce the amount of irrigation water that comes from drinking water. |

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| | Commune level utilities<br>Consolidating more communes into shared water utility service provision (increasing integration and connectivity as in Les Bagnes and Martigny) to better manage periods of high demand or scarcity – spreading water reserves across hydrologically diverse communes. | 30–40 years ago the water resources of many of the alpine villages were separate, meaning that if there were villages with fewer springs or more vulnerable sources of water, they would have to deal with this alone. By connecting resources, and linking vulnerable villages (with perhaps only one spring) with other, more water abundant, villages, supply was secured across the geographic area. |
| | Water Canals (Suonen/Les Bisses)<br>These irrigation canals form part of common property resource regimes that were initially developed and constructed in response to drier climate. The irrigation channels and associated water rights are governed through user groups and canals. | In certain communes, the original 'Geteilschaft/Gnossenschaft' are used to manage rivalries and govern the water system amongst farmers, but these tend to be more important in the mountain communes. |
| | Krisenstab<br>(Emergency Working Group) to respond and plan for emergency situations. | Each commune has their own emergency working group that consists of police, firefighters, military and commune council who are responsible for planning and coordinating emergency situations in collaboration with the canton. |

This definition therefore takes into account both proactive and preparatory adaptation as well as reactive and autonomous adaptation (Dovers and Hezri 2010; Engle 2010; Tompkins and Adger 2005). Actions and mechanisms included in this table represent legislation, or particular articles, regulation, policy frameworks or institutional actions (i.e. decisions or rules of user group associations) that provide guidance or mechanisms for drought or flood management, the prioritisation of users during particular peak periods (scarcity or high demand) and infrastructural adaptation to shifting hydrological patterns. While the Swiss case area covers adaptive mechanisms relating to both flooding and scarcity situations, the Chilean examples pertain only to drought and scarcity. The definition is deliberately broad and evades an exclusive linkage to climate change impacts since other studies have highlighted the difficulty in separating 'pressures exerted as a result of climate change from other economic, environmental or developmental pressures' (Tompkins and Adger 2004, p 564).

Across the two cases areas, adaptive actions ranged from historical coping techniques to legal prescriptions for prioritising uses in periods of scarcity to more radical policy reform. Unsurprisingly, the mechanisms for dealing with drought and flooding were very different, but lessons can be drawn from the institutional processes that allow for these mechanisms to be implemented. Other studies (e.g. NeWater) comparing adaptation across case studies experiencing flood or drought impacts have noted that flooding tends to illicit more advanced strategies (Huntjens et al. 2011).

The NeWater project suggests that this may be explained partly by different risk perceptions (Green et al. 2007) and the difference in available solutions to the two extremes, which itself is related to the unique natures of the different extremes. Huntjens et al. (2011) posits that flooding is primarily a safety concern, while drought management concerns water scarcity and allocation management problems. The suggestion seems to be that drought and scarcity issues can be seen as more polemic and divisive than flood management issues, with less potential technical and management fixes available. While the adaptive actions across the Chilean and Swiss studies are quite different, interestingly, the nature of the Swiss flood management solutions can be seen to be as polemic as those of the drought issues within the Chilean studies, on which the following sections will go into more detail.

## 10.2 Characterising Adaptive Responses

Adaptive responses in each of the case areas were categorised according to the concepts of transformation, persistent adaptation and passive change, as discussed in Part I. By categorising the responses in terms of these categories, it allowed a linkage to be established between governance mechanisms that allowed for more sustainable and resilient approaches to water management solutions and those that fostered responses that might not build adaptive capacity or even degrade resilience in the face of increasing stresses and uncertainty. In addition, in order to characterise the governance elements that were associated with different categories of adaptive responses, a mixed methods analysis was conducted in MAX QDA to identify the intersections between the different response categories and the governance related indicators (under three broad categories of *Regime*, *Knowledge* and *Networks*) to establish which governance mechanisms were most associated with different categories of response.

The following tables represented in Figs. 10.1 and 10.2 present the analysis and subsequent results of this coding exercise, which show a higher concentration of transformative and persistent adaptive responses in the Swiss case area than in the Chilean case area. The results of the coding exercise of the adaptive responses will be presented and discussed below, in conjunction with the governance indicators related to them.

### *10.2.1 Transformative Adaptation*

Transformational responses were classed as those that exhibited examples of *innovation, and possibly transformation of SES into trajectories that sustain and enhance ecosystem services, societal development and human well-being* (Folke et al. 2010). Transformability has also been described as the 'capacity to create a fundamentally new system when ecological, economic, or social structure makes the existing system untenable' (Walker et al. 2004). Adaptive responses were coded as 'transformation' if they exhibited traits of managing for uncertainty (i.e. practices and policies that prepare for uncertainty in context of climate change or inter-annual variability, including unanticipated changes), or if they showed that policy makers for/and water managers were searching for alternative governance or management practices that integrate ecological and social consideration, or had signs of innovation and development of new strategies that enhance ecological and social aspects as well as economic. A full list of criteria is given in the tables in Figs. 10.1 and 10.2, which show that of the adaptive responses, very few exhibited characteristics of transformation. Within the Chilean case, none of the responses exhibited transformative characteristics, while in Switzerland only the TRC and MINERVE had transformative attributes, and only the TRC could be categorised as 'transformation' (albeit with limits).

Initially, a scoping study was conducted to assess the most vulnerable areas, in terms of potential flooding events and damages (e.g. industrial sites and residential zones). In addition, the concept of 'residual risk' has been applied to the scoping studies for the project in order to meet the challenge of designing a project that incorporates the uncertainty of climate impacts (modifications in flows) so that the management plan can adapt to changing hydrological parameters. Engineers recognised that the project would need to find a means of incorporating hydro-climatic uncertainties to ensure that the project could statistically calculate projected levels of flow for individual sections under climate change conditions. Engineers are currently assessing the possibility of the calculated levels of flow being exceeded, and

| Analytical categories | | Adaptive Action / Policy Response | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Presidential Declaration of Drought Zones | Irrigation Efficiency | Water Data System Improvement | Aconcagua Project | Water Transfers | Turno | Farm level adaptations |
| Descriptive | Responsible Institution | DGA | CNR | DGA | DOH | ESVAL | Junta de Vigilance | |
| | Description | Declares of a drought zone for a maximum of 6 months; DGA may intervene on request in the management of the river and redistribute the water; extraction of superficial or subterranean waters without rights allowed; human consumption of water prioritised. | Provides financing and subsidies to farmers to improve irrgiation efficiency; administered and implemented by the CNR. | New government prioritised the improvement of the public information system for water rights, including transparency; better information is seen to enable better managemnet of resources in increasing scarcity. | Initated in 2001, with the purpose of constructing a dam at Puntilla del Viento, along with 2 other dams, and a battery of wells that would recharge from the dam in order to improve the irrigation sectuirty and allow for water transfers to La Ligua. | Water transfers have been conducted between the Aconcagua River to La Ligua, Limache and Marga-Marga using trucks to transport the water across during drought periods. | Process employed during drought periods to manage a proportional reduction of water rights and distribution of water to different users on a specific daily shedule | Crop Choice<br>Extraction of underground water |
| | Legal Baseline | Water Code, 1981 (Art. 314) Resolution 39 (1984) | Law on Promoting Irrigation Efficiency (Law 14.450) | Water Code (Cadaster Public de Agua) | Water Code (Infrastructure development) | Water Code | Traditional Method | Traditional Methods |
| | Status of Implementation | In effect | In effect - but loosing institutional support | Policy priotiy, not yet completed | Not yet implemented | Ad hoc adaptations | Ad hoc adaptations | Ad hoc adaptations |
| Transformative Adaptation | Paradigm Shift: Altered way of thinking incorporated into management measures or regulatory regime | No | No | No | No | No | No | No |
| | Climate change & uncertainty being addressed (inter-annual variability; unanticipated changes) | No - Resolution 39 establishes the 3 criteria for the DGA regional office to call a period of drought based on data from 1984. | No | No | No | No | No | Yes |
| | Incorporation of criteria for sustaining and enhancing ecosystem services, societal development and human well being | Limited - domestic supply prioritised | No | No | No | Only in that it prioritses water for domestic use | No | No |
| Persistent Adaptation | Recognise uncertainty and climate related drivers in adjusting responses to changing circumstances | No | No | Yes | | No | Yes | Yes |
| | Social Infrastructure: Development of Actor Network; Knowledge base | No | No | Yes | No - but it has led to the development of the Mesa Technica de Aconcagua | No | Partly - initiates period of increased and intense communication and cooperation between sections and canals for risks sharing | No |
| | Efficiency & Conservation | No - focus on exploiting groundwater resources in drought | Yes | No | No | No | Partly - signals to farmers period where water resources need to be conserved | Yes |
| Passive | Technical Infrastructure | Yes | Yes | No | Yes | Yes | Yes | Yes |
| | Focus on up-scaling past techniques that may still degrade the SES | Yes | Yes | No | Yes | Yes | Yes | Yes |
| | Category | PASSIVE | PASSIVE with elements of P.A. | PERSISTANT ADAPTATION | PASSIVE | PASSIVE | PERSISTANT with elements of P | PERSISTANT with elements of P |

**Fig. 10.1** Overview coding of Chilean adaptive responses

| Analytical categories | | Adaptive Action / Policy Response | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | TRC | MINERVE | KRIZ/CERISE Krisenstab | Suonen / Les Bisses | Municipal Priority Setting | Informal Use Transfers | Integration/Consolidation |
| Descriptive | Responsible Institution | TRC Coordination Commission | Canton du Valais | Commune Council | Water Associations | Commune Council | Commune Council / Utilities | Commune Council / Utilities |
| Descriptive | Description | 169CHF million project to reinforce flood security in the Rhone valley, with a number of sub-objectives to enhance social, ecological and economic security and well-being. | Canton iniative (linked to TRC) to improve the modelling of extreme events and natural hazards, their retention and effects; includes EPFL, MeteoSchweiz, and a group of hydropower companies | Early warning system to respond to flood & avalanche hazards; comprises canton geologists, river work engineers, natural hazards division, with MeteoSchweiz; links with commune krisenstab | Common property resource regimes that were initially developed and constructed in response to drier climate; still used to manage rivalries and govern the water system amongst farmers | Ad hoc municipal level directives for reducing water use in periods of drought; municipal provisions prioritise historic flow rights to agricultural users. | Local agreements for use transference and priority setting; commune regulations determine when the utilities are able to decide to supply farmers with domestic water | Consolidating more communes into shared water utility service provision to better manage periods of high demand or scarcity by spreading water reserves across hydrologically diverse communes. |
| Descriptive | Legal Baseline | 721.100 Federal Law on management of watercourss (1991); 721.1 Cantonal Law on management of watercourses (2007) | | Art. 31 kRPG | Commune rights registers | Art. 42 Law on the Use of Hydropower; Commune private contracts and agreements | Commune contracts and agreements | Inter-commune contracts and agreements |
| Descriptive | Status of Implementation | First Implementation Phase | Implementation Phase 2008-2011 | 3 out of 23 regions in VS functioning | Traditional Method - In effect since 13th Century | In effect | In effect | |
| Transformative Adaptation | Paradigm Shift: Altered way of thinking incorporated into management measures or regulatory regime | YES Structural change in watercourse management legislation | No | No | No | No | No | No |
| Transformative Adaptation | Climate change & uncertainty being addressed (inter-annual variability; unanticipated changes) | Yes - buffers for future flows, and iterative planning process in light of uncertainty in climate impacts. | Yes | No | No | No | Yes | No |
| Transformative Adaptation | Incorporation of criteria for sustaining and enhancing ecosystem services, societal development and human well being | Yes Ecological resilience of the floodplain incorporated into implementation plan | No | No | Yes | No | No | No |
| Persistent Adaptation | Recognise uncertainty and climate related drivers in adjusting responses to changing circumstances | Yes | Yes | Yes | Yes | No | Yes | Yes |
| Persistent Adaptation | Social Infrastructure: Development of Actor Network; Knowledge base | Yes - develops knowledge based, while participative process is expected anyway | Yes - New stakeholders and networks being developed | Yes | Yes | | No | Yes |
| Persistent Adaptation | Efficiency & Conservation | No | No | No | Yes | Yes | No | Yes |
| Passive | Technical Infrastructure | Yes | No | No | Yes | No | Yes | Yes |
| Passive | Focus on up-scaling past techniques that may still degrade the SES | Mixed - compromise has been made in implementation phase that still employs less innovative techniques | No | No | No | No | Yes | No |
| | Category of change | TRANSFORMATIVE Policy priorities are potentially diluted in implementation | PERSISTANT with elements of T | PERSISTANT Focus is on developing knowledge base and networks | PERSISTANT | PERSISTANT WITH Elements of P | PASSIVE With elements of P.A | PERSSISTANT |

**Fig. 10.2** Overview coding of Swiss adaptive responses

**Box 10.1** A Brief History of the Rhône Corrections in Canton Valais (Source: www.vs.ch/Rhône)

The Rhône Valley has historically been a site of numerous natural hazards most notably flooding, avalanches and landslides. Prior to the first correction, there had been numerous attempts to control the river in order to protect both inhabitants and infrastructure. However, an overall co-ordinated plan had escaped these efforts, limiting their efficacy across the broader region. After a devastating flood in 1860 that impacted on the entire valley, the first programme of corrective interventions took place on the Rhône River between 1863 and 1893. The results were, however, disappointing. Despite the dredging of the river, levels continued to rise. The second correction took place between 1930 and 1960, reinforcing and raising the level of the dikes that had been constructed in the first correction. The works were accompanied by an increased exploitation of the river bed, with companies beginning to remove the gravel for commercial purposes but also assisting in flood protection.

The third correction planning phase was announced in 2008, in a process that is set to take between 25 and 30 years. After a series of high flooding events in the 1980s and 1990s (1987, 1993, 2000), it became clear that the engineering corrections of the first and second corrections were no longer enough to protect the growing towns in the Valais from the increasing amounts of precipitation and melt that were having devastating impacts, and that a new tactic was needed. While the 2000 flooding event was a turning point, cantonal authorities had identified the need for a new set of corrections well before that catastrophe. The 1992 change to the federal law signaled a move to a more integrated approach to water management, including flood management. The 169 million CHF provided by the federal government for the TRC represents 65% of the project's costs, more than they are legally bound to by the WBG (45%), because the costs of potential damage and required measures are so comprehensive. The federal guidelines for the project's financing require it to integrate climate change uncertainties and to take account of social-ecological benefits, rather than just technical security and economic priorities.

where supplementary corridors of evacuation (*couloirs d'evacuation*) may be situated in order to manage this eventuality. The TRC project team therefore proposed an interpretation of the legal basis to the federal office, in which they proposed that for the project to be fair and balanced (i.e. fulfilling its security function and enhancing the ecology of the Rhône floodplain) the Rhône should be enlarged to roughly twice its current size.

However, while the TRC has transformational characteristics in its policy formation, the challenges of passing its implementation plan at the local level has led to a dilution of those attributes, which aim to enhance the ecological and social benefits of the projects. While the highly participative process in itself would be considered to be requisite for a transformational governance approach, in this case it also shows the deep challenges that it may also bring, to the detriment of innovation. Once the priority measures were identified, an interpretation of the legal baselines was conducted to draw up an implementation plan which identified the level to which it was possible to achieve a two times enlargement of the Rhône, or where the enlargement needed to be scaled back in order to take account of occupied land by urban zone or industry. The compromise was to complete a security enlargement of 1.6 times the current river size, with a more consequential 2 times enlargement in other areas. It is hoped that this will meet both federal demands, but reduce disruptions to more heavily urbanised and industrialised areas.

Windows of opportunity generated by successive extreme events that surpassed past management practices and technologies have limited currency when policy and engineering innovation meets the reality of implementation within a physically (urban and industrial reality) and socially (land rights and perceptions) constrained reality. The participative process of project implementation allows for the integration of these different voices, to ensure a socially equitable solution, but yet may result in a dilution of the principles that allow for greater resilience to climate uncertainty.

In Chile, despite the availability of scientific information on climate change impacts and sector impact studies, adaptive actions did not account for uncertainty in the context of climate change (particularly given that the development of inter-annual variability in relation to ENSO – El Niño/La Niña events is currently one of the areas of climate science with the largest amount of uncertainty). Environmental impacts and the ecological integrity of the social-ecological system are not considered outside of economic parameters, and innovation is generally low, with a reliance on classic technical fixes of large scale dam storage and increased groundwater exploitation. While water conservation and efficiency improvements are active or within the scope of governmental bodies (DGA focus on efficiency), the CNR is at present scaling back its irrigation efficiency programmes (notably to focus more on improving information and transparency of the water market). Yet, within the current framework conditions, these programmes do not lead to reductions in water use, but the expansion of supply or irrigation with the water that is conserved.

#### 10.2.1.1 Associated Governance Mechanisms

Regime

A mix of federal legislation (WBG, Federal Policy Directives) and cantonal legislation (Valais WBG) set the framework for the most transformational elements of the TRC (integration of uncertainty and climate information, integrated risk management based on social-ecological resilience). Environmental provisions within these laws and environmental goals integrated into subsidy programmes such as the NFA, attempt to direct water resources management projects and agreements on water resources in a in a direction that would allow transformation of the SES onto a trajectory that could sustain and enhance ecosystem services, societal development and human well-being (WBG, Art 4 (2), Valais WBG, Art 14)[1] (Valais 2009).

Knowledge

Planning time horizons were shown to be insufficient for current challenges, therefore longer term horizons were set, shifting the planning focus to more iterative and integrative and uncertainty (variable risk) based strategies. This was enabled through a diverse range of impact studies and multi-stakeholder investigations to allow for compromise and balance in the project. The integration of climate change adjusted risk and uncertainty into planning was deemed necessary to ensure that time would not be wasted in the future by having to redo the management plan (reflecting the understanding that present day hydrology might not reflect future patterns). Planning and scoping was therefore forward looking, acknowledging that current levels of flows may be surpassed in the future. Within the project itself, the enlargement (by 2 or 1.6 times) signifies redundancy being built into the system (Valais 2009).

An element of flexibility needed to be incorporated into the TRC plan to deal with this, so that the technical experts, rather than politicians, can define the planning process, but overall objectives are set in a top down manner from federal and canton levels (but their strength and closeness to interpretation is negotiated at the local level). Scientific and technical monitoring and modelling are relied upon to diagnose vulnerabilities, and communication programmes tend to translate the outcome studies into justifications for the project with local level stakeholders. Sustainability criteria are integrated into financial incentive criteria and thereby are positively linked with project objectives.

Networks

The distributed legal structure (i.e. canton and federal law) allows for negotiation between canton and federal levels to find a balance in the implementation of legal provisions which encourage a ‘sustainability’ led approach that matches both federal guidelines and local realities. Reliance on federal financial support allows the federal (more transformative approach) to have some power, but regional particularities and needs are accounted for through the decentralised implementation structure, which in turn is influenced by local autonomy, land rights holders and water owners. Each scale has its own source of power and agency (federal: legislative provisions, financial capability; canton: subsidiarity of Implementation as a constitutional right, technical

[1] Refer to the Management Plan of the TRC for more discussion on the acceptance that absolute security against flooding was no longer an option, and the development of the legal framework for the management of watercourse in conjunction to this shift in thinking. Available online at: http://www.vs.ch/Navig/navig.asp?MenuID=16521

expertise, some financial power over the communes; local: right to local autonomy, water sovereignty, land rights) leading to an extenuated impasse in passing the implementation plan, but the potential to negotiate a common, integrated solution.

### *10.2.2 Persistent Adaptation*

Responses that allow for the 'persistence of the fundamental properties of the current system through adaptation' (Chapin et al. 2009, p 20) were classified as 'persistent adaptation', to distinguish it from *transformative adaptation*. Adaptive responses were coded as *persistent adaptation* if they exhibited aspects of technical or governance innovation, which while they may not be transformative in terms of fostering SES resilience, it still introduced new, innovative approaches to decision making or water resource management. Examples of governance innovation might be the attempt to generate new or enhanced knowledge or partnerships for addressing resource challenges. Examples of technical innovation could relate to the development of new techniques or improvements to irrigation efficiency (new irrigation technologies or efficiency gains through infrastructure maintenance and repair), or hard path infrastructural solutions for scarcity, drought, rivalries or flooding, that also incorporated aspects of uncertainty relating to climate change.

Adaptation is deemed to be a manifestation of adaptive capacity, notably as a means of reducing vulnerability to present stresses and future impacts (Smit and Wandel 2006). However, this form of adaptive behaviour is more associated with means of 'coping' with climate variability rather than shaping responses to climate change that improves resilience of the SES, and adapting to the changes in physical parameters of the system. Boxes 10.2 and 10.3 below highlight two of the responses that were categorised as *persistent adaptation* responses according to the criteria above: the Turno from Chile and the MINERVE project in the Swiss case. The Aconcagua project also meets certain criteria of *persistent adaptation*, but the focus on steady state hydrology and the lack of integration of climate based uncertainty projections into the scoping plans, means that it was more heavily weighted as a *passive* response, and so shall be discussed later.

MINERVE represents a governance innovation in the knowledge network that frames the cantonal response system to extreme hydrological events. It incorporates a number of transformational characteristics in its fundamental integration of uncertainty based science and cross-sector partnerships for knowledge sharing in the public-private partnership. However, since it represents an innovation in only the information system for improving response to extreme events, it does not have the more transformative characteristics of shaping the broader resilience of the SES.

**Box 10.2** Turno in Chilean Irrigation Systems (Source: Interviews; Alvarez (2005))

The turno is the process employed during drought periods to manage a proportional reduction of water rights and distribution of water to different users on a specific daily schedule. The system of turno is a very old traditional Spanish system of proportionally reducing the amount of water each rights holder receives, but attempting to ensure that all the rights holders receive a proportion of their water rights. The turno is divided into shifts, which lasts a certain number of days. For example, if there are five zones to a canal, each zone will receive water for 7 days. So the first zone is allocated water for 1 week, and then the next 4 weeks they receive no water. During the time that it doesn't receive water, the zone is dry, and the other zones are allocated water in their shifts. The turno can take place between a single sub-canal, across a number of canals within one section of the river, or across multiple sections of the river. It tends to highlight the latent power imbalances between upstream and downstream water users, as well as those with stronger and weaker rights within a single canal or section of the river (Alvarez 2005).

**Box 10.3** Integrated and Coordinated Action Against Flooding: MINERVE (Source: http://www.aqueduc.info)

The project stands for 'Modélisation des Intempéries de Nature Extrême, des Retenues Valaisannes et de leurs Effets' which is the initiative by the canton to improve the modelling of extreme events and natural hazards, their retention and effects. The project represents a public – private partnership between the Canton Valais, l'Ecole Polytechnique Fédérale de Lausanne (EPFL), Météosuisse, as well as a selection of hydropower companies. In 2002, EPFL and Météosuisse were engaged in order to develop the information management system. Drawing on meteorological forecasts from MétéoSuisse, the system calculates the flow rates up to 72 h in advance, in order to provide water managers with enough time to put into effect anticipatory actions that should minimise flood damage.

The project also takes into account both the impacts on hydropower operations and reservoirs, as well as the potential role that they might play in adaptation to increasing numbers of extreme events. The aim is to develop multi-use infrastructure through innovative partnership techniques. Hydropower operators have been in negotiations with the canton to secure extra storage in hydropower

(continued)

**Box 10.3** (continued)

reservoirs as a means of limiting the impacts of flooding events and other natural hazards. When there is prior knowledge of a heavy precipitation event, hydropower companies are warned so that the reservoirs (*Speicherbäche*) can be automatically lowered to buffer the volume of precipitation.

In addition, MINERVE acts to mobilise a number of competencies to respond collaboratively to extreme events. These include meteorologists, hydrologists, information technicians, dam operators, security services (police etc.), as well as vertically coordinating decision making between the canton and communes. Over the 3 days of the 2000 flooding event, there was a degree of uncertainty with the canton over who was responsible for deciding on management steps to protect areas below some of the reservoirs. The lack of oversight and preparatory steps to manage over-flow of the reservoirs was seen as having been potentially counter-productive, perhaps even exacerbating some of the impacts lower down the valley. Now, in a selection of reservoirs across the canton, at the signal that there will be an extreme precipitation event, the reservoirs can be automatically pumped out and lowered, in order to then buffer the volume of precipitation that comes down.

It is also worth mentioning the institutional component of the Suonen/Bisses in this category as well. Cantonal Authorities have recognised that these common property regimes have played an important role in building solidarity and managing conflict resolution (Netting 1981), and therefore have made efforts at both commune and canton levels to support and encourage the maintenance of these organisations since they assist in the upkeep of the infrastructure and minimise costs at the local level. Federal and cantonal administrative levels provide financial support for the CPRs by subsidising infrastructural maintenance projects. The rest of the costs are covered by the commune and whatever then remains must be covered by the landowner, despite some, who are no longer farmers, being hostile to covering the costs for irrigation installations.

#### 10.2.2.1 Associated Governance Mechanisms

Regime

Mechanisms (legal provisions; informal agreements) that allow for emergency drought responses to kick into action provide a clear signal to actors that a different set of parameters have been reached, and so prepare the path to set coping strategies that replace normal ‘day to day’ management. In Chile, the drought provisions provided in the Water Code, signal that farmers may start negotiating emergency short term exploitation of groundwater to enable irrigation to take place as surface waters diminish. The emergency drought provisions allow for the flexible and provisional use of alternative water sources (wells/groundwater) as a means of short term coping, but also provide protection for groundwater rights holders who may hold the DGA liable for any affectation of third party rights. However, the effectiveness of the declaration is limited to the level of government financial assistance that would allow farmers to actually exploit the water resources to which they've been granted temporary access.

Adaptation at the Junta de Vigilancia and Canalista level is characterised by the Turno, which enables farmers to quickly shift to an alternative water distribution model. The model of temporary coping allows for the proportional reduction of water rights distribution based on different 'shifts' or 'turns', aims to minimise drought impacts across the basin (Box 10.2). In Switzerland, company and association agreements are in place between different actors (e.g. commune utility and farmers; commune utility and cable car companies; hydropower utilities and cable car companies) for short term adaptation of water supply for irrigation and artificial snow production. In addition there are commune level regulations on water provision during emergency times that provide guidelines for supply and sanitation in extreme events, but there are no overarching rules on scarcity or drought.

#### Knowledge

In Chile, the initiation of declaring the drought zone is guided by an internal technical regulation of the DGA, which sets the hydrological parameters by which drought should be declared. However, the present regional DGA office deems these parameters, and the data that informs them, to be out of date, and no longer relevant to the decision criteria for which it is needed. Despite challenges in the breadth and transparency of state monitoring and assessment, mechanisms are in place at the channel and junta level to evaluate the amount of water every day and proportionally reduce allocations during times of stress. Private actors also are open to learning from other areas and seeking government support for diversification and technical adaptation options as a potential means of coping with climate change impacts. Government actors have the technical capacity to carry out and use research on climate change impact across the water intense sectors. Increasing attention is being paid by government bodies (DGA, DOH and CNR) on improving the state and transparency of hydrological assessment and water rights information to build capacity for managing increasingly scarce water resources, as well as to inform policies such as a National Dam Policy (hard infrastructural adaptation).

In the Swiss case, improvements are being planned and implemented for local level monitoring on run off and water quality from increased precipitation as part of the reaction plans for coping with impacts on quality and quantity (in relation to extreme precipitation events). Flood management planning takes into account the likelihood of increasing water risks from climate change as prescribed by the top down regional planning concept that involves both federal and cantonal levels.

Inventories of water infrastructure take place to inform redevelopment of diversity (Suonen/Canals) as a means of maintaining traditional infrastructure that minimises impacts in heavy precipitation events. Early warning monitoring networks and response systems are already in place for many other hazards across the canton, and are being improved specifically for increases in precipitation events related to changing climatic conditions.

In both cases, the awareness of impending climate change impacts drives actor's perception of the need to find solutions for the challenges it will bring. In the Chilean case, this is however often accompanied by the perception that more water needs to be captured so that less is lost to the sea. In the Swiss case, there is an awareness of quality, quantity and seasonality changes from climate change, as well as dichotomy of extremes (i.e. glacier reduction but more extremes) in the intensification of the hydrological cycle, particularly among the more technocratic hydropower stakeholders. Recent experiences of major floods and precipitation events had led to a high awareness of this intensification and thus implementation of technical protection measures (after 1993 event) that protected them in the 2000 events, but which are already seen as redundant according to current observational data. In both case areas, technical fixes are seen as the main or only means (irrigation efficiency, crop efficiency, irrigation networks, storage capacity/dams) of facing climate change challenges. In Chile, however, attention has turned to the importance of improving market transparency and information so that it may operate better. This is not seen as an adaptation measure, but as a means of improving the baseline administration of water resources management to be better prepared for increasing droughts and pressure on scarce water resources.

Networks

In the Chilean case, cooperation for coping takes place amongst private rights holders through formalised user based institutions. Rights owners are enabled to take responsibility to ensure 'coping' in times of stress, through institutional mechanisms for canal based adaptations (i.e. Turno). While the Presidential declaration of a drought zone provides for increased involvement and connection between user level and administration level, the incentives for cooperation between actors remain fraught. The declaration is seen not to bring the financial capacity for investment in alternative groundwater wells that are needed for increased exploitation during the 6 month period, indicating that without the government's financial assistance, its increased involvement in the management of drought is extraneous.

In the Swiss case, public-private partnerships (government, university, private hydro companies) allow for information and burden sharing to improve protection from flood damage. The partnerships enable collaboration across regional, canton and local (private) and commune (public) actors. Knowledge networks link local and regional managers with research institutions (private and public) and universities, so that scientific information informs watercourse management. Cross sectoral collaborations are in place to improve service and efficiency in the face of novel challenges, for which expertise may not be at hand at the local level. Specifically in MINERVE, there has been a transition from informal collaboration and assistance to a formalisation of the process and agreement. At the local level, communal institutions that are redundant during 'normal periods' (e.g. *Kristenstab*) mobilise quickly to impending extreme events. These flexible institutions contain both private and public actors. While the canton level provides coordination in extreme events, freedom and autonomy persists at the local level.

### *10.2.3 Passive*

In addition to the two categories of adaptive responses, a third category was utilised capture responses that contributed to the degradation of the system to a less favourable state, resulting from either a failure to transform and adapt (Chapin et al. 2009, p 20) or maladaptation. Responses were coded as 'passive' if they adhered to concepts of steady state resource management, impasses in planning and project process with no scope for resolution, or adaptation that further degraded either the social or the ecological system. Responses that were categorised as passive included the Aconcagua Project because although it is a project that has a climate adaptation element to it (managing storage does not necessarily imply maladaptation), it has been proposed purely in the name of irrigation efficiency and its planning is based on steady state principles that do not integrate the potential impacts that climate change may have on the validity of the project.

The Aconcagua project is seen by many agricultural stakeholders as the only means for enhancing the capacity of the system to cope with increasingly dry periods, hence the level of frustration that negotiations have run for 10 years without any resolution. Stakeholders often referred to the loss of water to the sea throughout the winter period and higher periods of precipitation.

**Box 10.4** Water Resources Planning: The Aconcagua Project (Source: Presentations by DOH, DGA & Agricultural Stakeholders at Universidad Catolica de Valparaiso, Quillota; (Matta 2011)).

The Aconcagua Project is a major infrastructural project that has been in planning and negotiation for the past 10 years. It is projected to provide irrigation security to existing cropland, while also enabling farmers to increase irrigated area (30 million ha) through enhanced security of their rights. The project is to build a reservoir (Puntilla del Viento) with a capacity of 110 million $m^3$ together with a battery of wells in the areas of Curimón, Panquehue and Llay Llay. The wells would be relied upon only in order to manage periods of

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**Box 10.4** (continued)

drought. Without the present regulating works, farmers see themselves as losing water to the sea in winter time, which then cannot be used for irrigation purposes in spring time. Currently, the aquifer is being used as an underground reservoir, pumped during periods when river flows are too low to supply rights allocation.

The major impediment to the implementation of the project is a disagreement between agricultural stakeholders with the DOH and the DGA over the availability of water rights for filling up the reservoir. The DGA is under pressure to allow the plan for the dam to be approved, but posits that as there are no more available rights in the Aconcagua Basin, irrigators themselves must use their own rights to stock the dam. The DOH has 400 million $m^3$ of eventual rights, yet as detailed earlier, these cannot be transformed into permanent rights through infrastructure, but the aim of the dam is to give security to permanent water rights.

#### 10.2.3.1 Associated Governance Mechanisms

Regime

The drought declaration in the Chilean case enables actors to cope in part by allowing the exploitation of 'vulnerable' ground water sources. Additionally, the informality of the Chilean governance approach in 'normal' periods leads to a lack of capacity and knowledge of the river when the 'external' DGA takes over at the most critical moment. This leads to wasted time and conflict possibilities heightened because of the government intervention. However, the intervention of the DGA is still seen as a necessary last resort. In the Swiss case, while legal guidelines exist for the management of increasing flooding issues (governmental policy guidance) there is a void of guidance and rules on scarcity or stress.

Knowledge

The Aconcagua Project is defined by criteria adhering to steady state resource management, since there is no accounting for uncertainty, nor incorporating inter-annual variability (i.e. ENSO), nor the integration of climate change related uncertainties into the project scoping phase. There is a lack of alternative options proposed, and ideological constraints persist, which limit the ability to experiment with alternative solutions. The private adaptations at the canal and river level are reactive measures, and there is a lack of planning that would enable more proactive preparation. The DGA intervention in the river implies a loss of knowledge, since government actors lack the capacity and familiarity of the basin as water management is usually in the hands of private actors.

The lack of agreement and coherence across different evaluations and assessments of the hydrological resources available in the Aconcagua, severely limits the ability of both public agencies and private actors to agree on plans for the development of management and infrastructure in the basin. There is a strong awareness amongst water owners that hydrological patterns are shifting, but as yet this has not translated to enhanced use of technology, monitoring, modelling or integration of uncertainty into the management and planning of water resources in the basin. The ideological rigidity of the water market and Water Code not only informs the adversity to change the framework rules which govern the current system but also constricts and narrows actors' views of how to resolve the complex problems that have been emerging. The Swiss case lacks preparedness and planning for possible scarcity situations in the area of water supply. This is in part due to the perception of climate change as an issue to be taken into account for long term horizon planning (30–40 years) but not yet for operational day to day management. While there is an acceptance and awareness of the inevitability of increasing impacts in flooding and natural disasters, awareness on other impacts of climate change related to water availability remains less engrained. Despite this, there is still awareness amongst technical experts that precipitation patterns are changing and that legal mechanisms for drought are no longer up to date.

### Networks

In the Chilean case, the lack of trust between actors is a major impediment towards fostering common integrated solutions to common problems. The impasse over the Aconcagua project has lasted for 10 years for example. Furthermore, the DGA perceives that the agricultural actors have strategically used legal mechanisms such drought provision as a means of forcing the DGA's hand on groundwater exploitation. At the ministerial level, the power imbalances between different ministries and government institutions (mining, energy, agriculture versus environment and water) has so far continued to side line the environment and weaker economic actors in water resource management, limiting the scope for innovation for enhanced SES resilience through cross-sector collaboration and cooperation. At the basin level, public-private sector cooperation has taken place within the realm of the Aconcagua Project, as well as between Junta de Vigilancia and individual companies. Private negotiation of this sort is reported to take the form of financial pay-offs (an alternate version of polluter pays, which does not lead to less pollution, but just an acceptance of it), while multi-sector cooperation in the Mesa Tecnica has not as yet led to a resolution on the project or to a solution being found.

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