Chapter 12
Operationalising Adaptive Capacity

Abstract Drawing on the three earlier analytical steps, presented in Chaps. 10 and 11, this chapter explicates the process of developing more nuanced indicators of adaptive capacity from the original determinants presented in Part I. Thus, drawing on the original determinants discussed in Part I, together with both outcome assessments and the emergent themes in the bridges and barriers analysis, the indicator section that follows will elucidate how the regime, knowledge and network based indicators could provide a framework to address the emergent issues from this set of analysis. The indicators and their operationalised criteria are presented, and contextual sensitivities across the cases are discussed. Finally commonalities and linkages across the different indicators are explicated.

Keywords Rhône, Canton Valais, Switzerland • Aconcagua, Region V, Chile • Operationalising adaptive capacity • Nuanced governance indicators of adaptive capacity • Challenges across scales

12.1 Triangulating Towards a More Nuanced and Empirically Based Set of Adaptive Capacity Indicators

To recap, the initial set of determinants, drawn from the literature, were used to explore adaptive capacity through semi-structured interviews in order to gather information that could be used to assess the forms of adaptive responses in relation (but not exclusively) to climate related stresses and operationalise the determinants into more nuanced indicators and their criteria. The first chapter (Chap. 10) in Part III presented the analysis and characterisation of the adaptive mechanisms identified across the difference governance scales according to the categories of transformation, persistent adaptation and passive responses. The correlating governance mechanisms were discussed in relation to the different categories of adaptive action to

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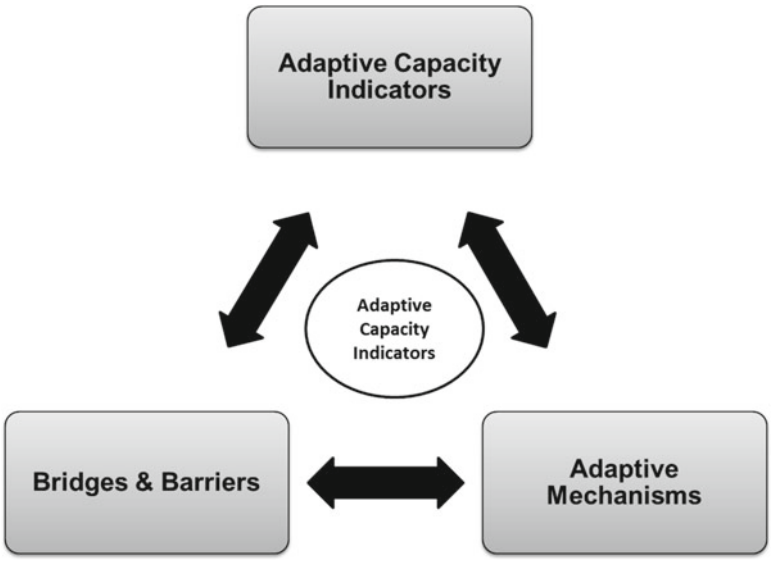

Fig. 12.1 Triangulating towards a more empirically grounded understanding of governance related adaptive capacity indicators

generate a better understanding of the governance actions associated with more transformational adaptation.

Next, analysis of bridges and barriers to adaptation in relation to extreme events allows a better understanding of adaptive capacity to be built up, primarily through the identification of a set of favourable conditions for fostering adaptive capacity. The process of analysis of these sets of conditions that help or hinder adaptability to extreme events, combined with the analysis against different forms of adaptive action were both important steps, combining both inductive and deductive techniques, to identify common themes across the case studies that allowed for the development and operationalisation of a set of indicators from the broad determinants of adaptive capacity (Fig. 12.1).

12.2 Regime

Regime refers to the sets of rules, legal and property rights framework, which determine what water stakeholders can and cannot do. It relates to the ownership and use of water resources as well as the rules and regulations that determine the management of the water resources, which water rights owners must follow. It encompasses the legislative and regulatory framework as well as the property rights system and policy framework. It also comprises the dynamics and power relations between

different political and administrative levels from federal or national levels, to regional governments and administrations, to local level authorities or user associations (Table 12.1).

12.3 Knowledge

Knowledge refers to the informational inputs into a governance system that determine what actors know. These indicators encompass elements in the system, which allow for holistic and balanced management decisions that incorporate not only economic, but social and environmental information. It also establishes how uncertainty, and potential heightened levels of uncertainty, is accounted for in decision making. It refers to the timeframe in which plans and management techniques are evaluated and implemented, and the scale at which climate change or adaptive capacity is considered as relevant to the effectiveness of evaluation and planning under changing climatic conditions.

Perceptions of change also influence planning and management decisions. Available and accessible information and knowledge is vital for informing adaptation decision making, including the use of climate and hydrological information systems, effective deployment of 'objective' scientific information across different networks or levels of decision making, and the integration of different kinds of knowledge into decision making (e.g. traditional knowledge and experience). Monitoring and assessment frameworks are of course a primary requisite to ensure that adequate levels of information about water resources are available (Table 12.2).

12.4 Networks

Networks refers to the way in which actors interact and cooperate. It encapsulates the connectivity between groups and stakeholders that allows knowledge to be shared and common solutions to be negotiated for integrated solving of complex challenges. However, connectivity alone may not imply a willingness to cooperate during extreme climate stress, which demands accessible, expedient and effective conflict resolution mechanisms. The level and type of interaction between different stakeholders within the basin or sector also influences the motivations for connectivity between groups to cooperate and find common ground for building, as does the mode of coordination and delegation across different political and administrative layers.

Mismatches between authority in rule setting and lack of agency in management can deadlock actors on water management issues, diminishing the actor system's ability to resolve increasingly complex problems. One important aspect of networks is that the means of integrating scientific information is integrated into decision

Table 12.1 Operationalised indicators of adaptive capacity relating to regime components of the governance system with case examples

		Case example	
Regime indicators	Operationalisation	Chile	Switzerland
Ownership	*Consistency & Certainty*: To avoid recurring fundamental shifts in rights and governance frameworks from government to government. Legal certainty around ownerships and use rights is required for water owners and investments in water rights.	Multiple changes in legal framework (Agrarian Reform, Water Code) over the past 50 years has led to a situation where the rights ownership framework is opaque and unclear – yet inflexible in adapting less water (legal extraction can overrun actual availability). Water protected as a property right in the constitution providing high security and certainty to rights holders (but many of these are now seen as derechos de papel/paper rights.	Shifting relevance of traditional private rights, shifting institutions for their management. 80–100 year concessions periods for hydropower usage rights.
	Coverage: Coverage of all water rights/uses (removing blind spots from rights framework – e.g. glaciers, precipitation) CC means a closer eye needs to be paid to these unregulated areas.	Glaciers and groundwater have a weaker institutional framework than surface waters.	Increasing volumes of water for artificial snow production is currently unregulated, negotiated mainly through private company agreements; certain groundwater uses (agriculture) have no oversight, concessions or quotas.
	Clarity: In meaning of water rights (where they are fixed; how much the flow rate is; who owns them) and in application of the law and translation of legal framework to responsible parties/water owners at watershed, local to national levels.	Border problem with ESVAL & S2/S3; farmers exchanging rights, but no record; selling on rights, but still using them; process of legalising/institutionalising user groups can be impeded because of complex judicial and legal procedures; self-organisation - responsibility at the user level not happened for groundwater in Aconcagua.	Environmental flows are only to be taken into account in new concessions; EPA parameters for environmental performance lack clarity and precision; grundeignturm rights are very complicated, and therefore difficult for lawyers to really understand.

Responsibility	*Coordination*: Designated institutions need to have an overview to tackle the larger problems (i.e. unified perspective on cross sector issues, longer term issues).	Transference of water management to private sphere limits coordination and collaboration on trickier, longer term issues; projects are presented to MIDEPLAN only from their ministry's core perspective; no priority setting between sectors and uses; groundwater framework weak compared to surface water	Lack of cohesive and coordinated energy/water/environment policy across different administrative bodies.
	Rule setting: Finding a balance between decision making and political drivers of water resources management and the technical expertise required to build policy across the different levels and layers of responsibility: Ministerial Targets/Regulation; Judicial Decisions; Regional Regulations & Agreements; Local Directives, Agreements; Company/Association Agreements.	Water Code rules on the management of water rights, and its application is interpreted by the courts in individual cases. The individual water rights owners have the mandate to manage, and intervention/enforcement from public authorities has to be requested by a rights holder. Centrally driven water policy, determined by presidential priorities. Water provision regulated and prices set by a government regulator.	Designated levels of responsibility from federal policy to cantonal legislation and ordnances then to local directives (Bewilligung, Ordnung) and private agreements, creating linkages for enforcement and monitoring across uses and jurisdictions. Regulations differ per commune; canton legislation takes time to be in step with federal legislation and direction; private sector actors are responsible for implementation of certain restoration/re-naturalisation provisions.
	Expediency: Affordable and accessible access to informed judgements on water conflicts and issues within a basin.	Associations or the courts are responsible for resolving conflicts between users. Court process is lengthy, expensive and gridlock in conflict resolution prevents the legal institutionalisation of certain user groups, which erodes their ability to manage flows within their section.	Few court cases concerning water resources; administrative route provided for aggrieved parties to denounce planned projects at the relevant administrative level; participation in planning aims to pre-empt conflicts, but in TRC led to drawn out acrimonious negotiations in pre-implementation phase.

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Table 12.1 (continued)

Regime indicators	Operationalisation	Case example	
		Chile	Switzerland
Preparedness	*Pre-emptive provisioning*: Emergency provisions for hydrological extremes that can be initiated quickly for effective management of water scarcity or periods of flooding	Drought provision in Water Code provides for institutional response for drought management through a presidential decree according to technical parameters of Resolution 39 (1984). Informal institutional responses intra and inter JdV are invoked.	Policy frameworks for longer term flood management complemented by canton and local directives and management plans for pro-active and reactive flood response. No rules on scarcity management.
	Flexibility: Proportional Reduction of water rights; prioritisation of certain uses.	No prioritisation of uses in 'normal' periods; Tourno allows for proportional reduction of water rights within the separate sections of the basin; DGA prioritises domestic water, then irrigation during decreed drought periods; flexible reduction in rights distribution according to % of flow.	Priorities for set periods in canton legal framework; domestic water is prioritised during scarcity situations.
Integration	*Environmental Protection*: Provisions for the protection of aquatic ecosystems, including both quality and quantity provisions.	Water code differentiates between surface and ground waters; drought declarations allow provisional rights for surface- and groundwater and remove limits of ecological flows.	WPA provides for quality and quantity protection of waterways and aquatic ecosystems; environmental protection responsibility of Canton.

	Systemic Integration: Whether environmental provisions are just a 'tack on' that should be fulfilled if possible – or if sustainability of the SES is taken as a goal of the legislative framework.	Environmental protection framework is weak, with little monitoring and enforcement and weak EIA process; environmental flows unaccounted for in existing rights, only new rights; DGA's (responsible for surface and groundwater sustainability) technical criteria of sustainability have no legal basis, but are internal guidelines. MMA separately sets and monitors water quality (Norma secondarias de cualidad de agua).	Environmental flows to be accounted for in new hydropower concession period (but challenges in enforcement); social and ecological sustainability, and 'room for waterways' integrated into Cantonal Water Law (2008).
Accountability	*Neutrality*: Appropriate checks and balances to avoid agency capture in resource related ministries (e.g. National Commission for Energy, Mines) and to enable fairness across economically strong and weak actors.	Economic priority across ministries gear water management for exploitation; register of trades and rights happens with the Conservador, which is private but they have a monopoly for each region, and is under the control of the judiciary (with accusations of nepotism).	Provisions concerning project and planning proposals and EIA provide for multi-stakeholder input (VBR); environmental department responsible for evaluating EIAs from energy and other departments.
	Enforcement: Designated and clear lines of responsibility for monitoring and enforcing the application of legal provisions and regulatory requirements concerning water use and protection.	Self-enforcement amongst users for denouncing illegal abstraction creates challenges in the denouncement and punishment of water crimes, which exacerbates the impacts of drought periods on water courses; enforcement in the hands of the courts rather than DGA; Superintendencia is responsible for quality monitoring and ensuring water user does not exceed the utilities property rights.	Canton is responsible for enforcing legislation and regulations at local and canton level, but cannot impact on water sovereignty at local level; special 'water police' monitor/charge for illegal extractions and use.

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Table 12.1 (continued)

Regime indicators	Operationalisation	Case example	
		Chile	Switzerland
	Formality/Informality: Ability of regulators or water managers to enforce; nature of the relationship between the rule setters/ governors and those being governed (i.e. private sector); how hands off the approach is.	High autonomy of individual water rights owners; JdV does not have mandate to manage, but to enable just allocation of water rights; state has a subsidiary role, with public authorities lacking agency and capacity to manage water resources to incentivise cooperation across watersheds and attain more sustainable level of water management as well as limit level of illegal extraction; high number of unregistered rights and illegal abstraction.	Use of water and management of waterways is most strongly informed by cantonal law, which is required to remain in step with federal legislation. Federal state takes a back seat in water management. Communes are encouraged to manage the resource in a way that respects the legal principles only through the subsidy incentives. Hydropower operations are regulated through cantonal level laws and commune level contracts; levels of commune autonomy are particularly high in the Valais, especially in the high mountain communes, challenging enforcement.
Effectiveness	*Implement-ability*: Translation of de Jure provisions into de Facto outcomes - effectiveness of protection and use provisions for sustainable water management.	Payment for non-use to reduce hoarding has not worked in reality as farmers prefer to protect rights, and fees are negligible for hydropower and mining companies; aims of market distribution ineffective because farmers value security over profit under conditions of scarcity. Technical expertise hampered in implementation by political and legal constraints.	Complex interplay between federal/ cantonal legal provisions for sustainable and integrated water management and local level sovereignty; environmental flow provision is a point of tension between the energy, agriculture and environmental protection departments, in terms of implementation rather than legal provisions; conflicting view on implementation of TRC concept, pitting economy (agricultural land owners) versus ecology (political/environmental stakeholders).

Holistic: Provisions in legal and rights framework of incentive to use water efficiently and effectively across multiple uses, including incentives for conservation of water resources.	Water market led to highly connected supply and sanitation but no price for water (nor differential pricing according to use/sector) removes incentives for demand side or water balance management; Law 18.450 incentivises irrigation efficiency; inequities (upstream : downstream) and over-use (no environmental flows; full use of water rights volumes).	Focus on end of pipe solutions; lack of incentives/provisions for water conservation.
Capacity: Matching up resources at the level of enforcement	Lack of capacity in the DGA to administer water rights, transactions and hydrological investigations left to private actors; funds from MOP for drought response are low in years with other disasters (e.g. earthquake of 2010), limiting ability to implement projects to minimise economic impacts of drought.	Challenges in enforcement at canton and local level due to lack of capacity

Table 12.2 Operationalised indicators of adaptive capacity relating to knowledge components of the governance system with case examples

Knowledge indicators	Operationalisation	Case examples	
		Chile	Switzerland
Evaluation and planning	*Neutrality*: Limiting scale of subjectivity in research and evaluation inputs into planning decisions, i.e. opposing information and studies being used in the management of water resources to justify certain decisions on infrastructure, water rights or management pathways. A healthy level of diversity is in different techniques and researchers can contribute to the scientific robustness of decision making, but neutral quality assessment can remove bias.	Inter-linkage between political and technical aspects of water management disrupts, slows down and politicises technical assessments and their implementation, leading to contentions over the technical feasibility studies (pitching private consultancy assessments against the DGA assessments) of groundwater sustainability, the Puntilla de Viento Dam and related groundwater exploitation studies. Ability to create long term plans beyond the term of one president/administration is a challenge (e.g. IWRM plans of Bachelet government).	Sectoral motives infiltrate studies commissioned for the TRC; technical studies are used by both sides to justify 'their' proposed technique for flood management. Private engineering offices play a large role in technical support to municipalities in conjunction with public administrative departments.
	Reactivity/Longevity: Development of both short term coping strategies for ad hoc climate shocks and extremes (inter-annual droughts and flooding) and longer term adaptation plans for larger shifts from climate change impacts (changes in glacier melt, snow pack, seasonality).	Reliance mainly on traditional/ observation of rainfall amounts to predict preparation needs for a drought the coming summer at farm/ canal level. Uncertainty calculations and climate impacts not taken specifically into account in planning of large projects (e.g. Aconcagua Project).	Proactive and prophylactic approach to planning (10 year cycle of planning in hydropower sector; canton and municipal ordinances on disaster management procedures; local risk hazard mapping) flood management plans are cantonal and federal responsibility to be implemented at local level (warning times are about 6–8 hours). MINERVE generates short to medium term precipitation prognosis to forecast bad weather events and expected water volumes to be managed. For water supply, water quality safety systems indicate if spring levels are reaching critically low levels from 1 year to the next.

Inclusion: Integration of uncertainty and climate change into plans, through increased accounting for complexity and uncertainty in managing water resources. Integration of social-ecological-economic criteria (including a valid weighting to each component) as a means of better accounting for complexity and building resilience. Integrating conservation with efficiency, rather than the promotion of efficiency for increased exploitation of water resources.	Cost benefit analyses of water policy decisions in normal times (social discount factor = 6 %) and in extreme periods, e.g. of the losses due to the drought compared to the value of investing in pumps to tackle the drought (e.g. assessment of loss of VAT taxes through decreased production);physical consequences of the market are not accounted for in sector specific technical focus of adaptation options (i.e. desalination, national dams policy, irrigation efficiency, etc.) under consideration to meet rising demand under decreasing supply. Studies, modelling and seminars on climate change impacts, but approach is fragmented, lack of holistic and coherent cross sector/ministry strategy for managing and adapting to climate change impacts; climate change projections not included in forward modelling for Aconcagua Project.	TRC diagnosed the security of the Rhône, the quality of the dikes, deficits in terms of the size of hydro in order to meet security objectives, and improve the quality of the environment and the socio-economic aspects along the river, while taking climate risks into account through residual risk calculations. TRC implementation plan will not remain static and fixed, but 10 year evaluation period. Most vulnerable areas deemed priority measures, iterative approaches aim to balance sectoral priorities in implementation. Tendency for water supply on the other hand (irrigation, domestic supply) to take climate change into account is dependent on the municipality. Universities and private engineering consultancies conducting sectoral based studies; water protection office is taking part in an INTEREGG project with an Italian partner to observe springs in linkage with climate change. Climate change taken into account in planning and research but not at the operational level for hydropower. NFA as an incentive for inclusion of multi-criteria for integrated risk management.

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Table 12.2 (continued)

Knowledge indicators	Operationalisation	Case examples	
		Chile	Switzerland
	Applicability: Appropriateness of the data sets (time period, data points etc.) to the decision making process How data/findings are applied to decision making water resources – being able to apply information to decisions because they are in the hands of technical experts not just politicians.	Issue of wet years being used to assess water availability from which to make rights allocation; data set from which Resolution 39 is constructed is out of date against current hydrological parameters. Final decisions on projects rest at presidential level (on a 4 year rotation); 80 % water security measure over 30 year period to inform permanent water rights allocation, but in Copiapo, one wet year was chosen so abstraction is adjusted to a wet season as droughts increase. Difficult to find and apply data on environmental and social costs	Politically, every 4–5 years there is a new communal authority, requiring knowledge to be transferred and re-assimilated. Challenges to cantonal oversight from local level sovereignty of water and implementation. Technical and hydrological data informs the management of different sources of water (e.g. spring monitoring for domestic supply), with real time data and annual averages, as well as hazard response systems (MINERVE & CERISE). Application of data from measuring stations (e.g. expected flows) to flood protection plans for those communes that have completed implementation.
Monitoring and assessment	*Consistency*: Consistency in different data sets and information; consistency and coordination in collation of data.	Central perception in Santiago on functionality of water resource management differs significantly from that in the regions, where impacts of governance approach are experienced. Wide range of actors (public and private) conduct mapping investigations, but lack of clarity concerning decision making process on contrasting data.	MINERVE requires consistent monitoring of precipitation for increased accuracy in forecasting and prognosis (canton & hydropower); observations and evaluation responsibility presides at canton level, maintaining the overview over the municipalities for ad hoc extremes and longer term planning project such as the TRC. Hydrological data network is extensive but not target-oriented, and cross-over/discrepancies between different levels and sector involved in monitoring, and the different demarcations of responsibility.

	Diversity: Diversity of inputs into the decision making system, e.g. Early Warning Systems, Hazard Mapping, Water Quality Monitoring, Snow and Glacier Monitoring etc.	Technical capacity on monitoring is comparable to developed contexts, but disparity between technical expertise and the monitoring inputs available to administrative departments and water managers.	Trockenweiseninventar, Suoneninventar, Inventories on irrigation in fields and meadow, high collation of different data sets. Less data available on glacier melt contributions to run-off.
	Coverage: Extensiveness and accuracy of the monitoring network, including functionality of equipment and usability of data for accurate decision making.	State monitors snow and precipitation, but irrigators also rely on private meteorological stations (e.g. Mina Andina) for weather information. CONAMA responsible for water quality monitoring, DGA for water quantity monitoring (4× per year), ONEMI for enforcement of quality failures. Monitoring difficult to coordinate and then implement controls. No national network and no consistent and coherent annual/monthly/regular monitoring of quality issues. DGA recently initiated a Chile wide glacier monitoring programme.	Hourly quantity monitoring across public and private sectors; canton quality monitoring as part of a national network co-ordinated through the federal level. Private sector collaboration on monitoring network (e.g. Universities, Canton, Hydropower companies; Engineering consultancies establishing stream sediment monitoring). In mountain areas, monitoring network is less advanced than elsewhere, but more monitoring stations are being implemented to improve understanding of spring levels under climate change.
Transparency	*Availability/Coverage*: Availability of information on water resources and ease of access to that information across all water stakeholders, across both the public and private sectors.	Lack of available, systematised and accessible information on water rights, water judgments, water market and prices, and the health and availability of water resources. Public water registry is out of date,	Online publication and access of canton and federal data, plans (e.g. Kantonale Gewässersanierungs Plan, CERISE) across different platforms (MeteoSuisse, BAFU, vs.ch, planat.ch). Data on snow-production, water use, hydropower use are difficult to access, and spread across multiple companies and communes (though available

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Table 12.2 (continued)

Knowledge indicators	Operationalisation	Case examples	
		Chile	Switzerland
	Maintenance of water resources data to ensure relevance of the information to water management decision making.	and incomplete and non-electronic. Odepa.cl – available online data; DGA has no oversight on the trading and transaction of rights, market is seen as 'dark'; information on impacts in upper basin/mining companies is inaccessible. Multiple institutions manage water rights data (Conservador de Bienes Raises; DGA, Junta) – non-systematised and chaotic management.	online at many commune websites). MINERVE data sharing is still paper based in contrast to the online publication of plans and data concerning TRC. MINERVE implements a convention (signed between the owners of the hydro-power installations and the Valais) for an exchange of information during crisis periods.
	Communication: Resources and networks for communicating relevant information prior to and during periods of extremes. Communication for capacity building and education for building understanding on water and environmental conservation, including awareness on local climate change impacts and adaptation options.	Lack of education and communication on water conservation; personal and public communication (e.g. newspapers) on drought preparation, advice provision from JdV presidents on managing irrigation and crop production in drought periods.	Detailed communication of TRC through online communications, newsletters and participative fora to explain the justifications for why it is necessary to intervene on the watercourses, and to secure the plain. Attempts at canton level to be more pre-emptive in their communication with municipal level stakeholders. Local press and media used to communicate water supply provisions during scarcity periods and warnings during emergency flooding events. MINERVE convention provides for public communication during extreme events. Canton is legally required to ensure communication on habitation in hazardous areas and where houses can be built (flood and avalanche protection).

Perceptions	*Awareness*: Level of awareness amongst water managers and rights holders and government bodies of hydrological change and increasing uncertainty/ unreliability. Perceptive and sensitive to change but not reduced to apathy by it.	Observational awareness from irrigators and water managers that climate is changing, with reduced snow pack, melting glaciers and precipitation changes, but lack of popular awareness on water conservation; Acknowledgement that climate impacts will heighten and hydrological resources will be increasingly diminished; DGA/ Presidential acceptance of climate challenge.	Observations of change in the local climate (temperature, snow pack, timing of snow melt, glacier retreat, isotherm, permafrost) heighten the awareness of rate of climate change. In the region, engagement on climate is higher in the winter tourism and hydropower sector, where increasing glacier melt heightens hydropower production but increases material flows, in the reservoirs than in water provision, where communes mainly use non-concession spring water and there is a strong perception of Valais as the 'water tower' of Europe. Preparations for one scale of change (dry summers, glacier melt) but apathy towards more drastic ones (glacier disappearance, water scarcity).
	Openness: Openness to learning lessons from external experts and experiences, beyond their own perceptions of uniqueness. Ability to cope with change and willingness to bend to new management solutions or paradigms, while not retaining ideological rigidity.	Strong perception of the uniqueness of the Chilean model, therefore limiting ability to learn from other experiences. Old guard in some of the JdVs may be seen unwilling to move with the times; perceptions of success of the Chilean water market. MMA – other water/environmental authorities are looking very strongly to the experience in Europe of implementation the WFD; DGA/ presidential acceptance of weaknesses in the system/institutions – but not of the approach. Because of the uniqueness of the Chilean model, they do not think that it is possible for Chile to set up the same structure as basin management may follow in other countries.	Belief that historical adaptations to drier climate positions Valais agriculture to be better prepared than rest of Switzerland; research partnerships and knowledge exchange associations within and outside of canton suggest openness to learning from external experts and other regions.

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Table 12.2 (continued)

Knowledge indicators	Operationalisation	Case examples	
		Chile	Switzerland
Experience and expertise	*Experience*: Formation of experience for managing water resources in extreme periods through years of professional experience, social memory of past extreme events and droughts and training programmes. Different forms of experience; mix of technical competence and traditional knowledge for management of complex problems and novel threats.	Lack of professional training/education in water resources management for those private actors 'managing' water rights, for normal or drought periods. JdV/Canalista positions tend to be non-professional and part time. Strong role of tradition ('culture of water') and history in management of the canals. Experience of managing water scarcity differs from section to section and region to region. CNR/CORFO seminars and training programmes aim to improve management, techniques and efficiency and knowledge transfer in visits abroad. In drought management DGA relies on provision of technical information/parameters, while irrigators' intuition guides the management process. Lack of local knowledge/capacity in DGA drought interveners.	Disparities across municipalities and sectors; post-event debriefings occur at company level, allowing lessons to be applied to management of and preparation for future events; training courses on water management specialised for water management within different sectors through commune and cantonal administrations (e.g. L'association Valaisaine de distributer d'eau'; Societe Suisse de l'industrie du gaz et d'eau; Landwirtschaftzentrum; seminars on extreme events in Dienstelle für Naturgefahr). Long history of experience of rain shadow effect and annual training exercises on disaster response. Mix of experts in TRC (engineers, hydrologists, ecologists, territorial management etc.)
	Expertise: Conflict resolution processes need to be informed by both in depth legal knowledge, but also by the hydro-climatic and environmental impacts in which the judgement would result.	Court responsibility for resolving water conflicts result in judgements that steer the course of water management (ref Supreme Court decision on Factor de Uso). Local/regional judges may lack water specific expertise, leading to bad decisions.	Scope to improve technification in agricultural sector, farmers are increasingly part time, impacting traditional associations for management of irrigation right; at local level, commune presidents may assume responsibility for water management decisions, presiding over the post for short periods and on part time basis; certain water management responsibilities at local level (gefahrenkarte,.

Multiple forms and disciplines of expertise contributing to solution building for complex inter-connected problems, as faced by water managers under climate change.	and causing actors to circumvent the official process where possible. Level of technical expertise is high in water science, but ability to inform decision making and management from technical perspective is obstructed. Technification of water management in irrigation in the basin is mainly traditional (e.g. Bocatoma; irrigation efficiency; measuring/monitoring of canals; reliance on 'culture of water' rather than professional water management training). At government level, technical expertise is limited to hydrology and economics, no focus on public policy.	sanierung etc.) and canton level (NAQUA monitoring) tend to be outsourced to private engineering consultancies (though water suppliers have in house expertise as well) with the requisite expertise to work on the project in conjunction with the specialist cantonal department.
Secularism/Independence: Separation of political and technical management of water provision and management to ensure neutrality and continuity in water management beyond short term election cycles and political dogma (i.e. retaining knowledge).	Lack of independence and political secularism of scholars and experts informing water governance (collusions of World Bank, Neo-liberal politicians, economic agenda, financial contributions etc.). Operational/technical expertise at the regional level more functional than at the central political level.	Administrative departments involved with water management at canton and commune are not political appointees, but professional positions that remain in posts despite political outcomes. In commune councils elected officials constitute the political group and technical staff the service group for both watercourse management and provision; changes in legal framework are subject to or initiated by a broader range of stakeholder due to the direct democratic process.
Distinction between political and operational pools of resources; separation of political process and technical expertise on water management.		

making, i.e. the networks through which information is disseminated and shared. Collaboration and information sharing across different actors and levels elucidates the extensive and pervasive challenge of getting stakeholders to cooperate and collaborate either formally or informally (Table 12.3).

12.5 Contextual Sensitivities

Despite the cases being highly varied from both a physical and institutional perspective, common elements could be operationalised according to each indicator. Similar underlying challenges in developing and mobilising responses played out in different contexts and ways as the tables above indicate and the following section shall discuss them in more depth. Moreover, despite these different contexts, it is important to attempt to generate common lessons from contrasting systems since one of the challenges in climate change adaptation is scaling up local lessons to be applicable across different contexts (Herrfahrdt-Pähle 2010; Smit and Wandel 2006).

One point that should be addressed again at this point is the recognition that lessons have been drawn from both the flood and drought context. Despite the differences in the frameworks for responding and managing these hydrological situations, both provide important lessons into the governance mechanisms that influence adaptive processes. Notably, other studies that have compared the two contexts have also found that case areas confronted with recent flooding have more advanced strategies (according to AIM approaches), in comparison to drought response and adaptation (Huntjens et al. 2011).

Some studies have suggested the integration of a resilience based approach to be easier for flood protection than drought resilience due to the different kind of risk perception associated with each form of stress; moreover, the varying availability of solutions to flood and drought (Huntjens et al. 2011) make it easier to bring stakeholders together to find more innovative solutions in the window of opportunity after flooding events, where safety is the primary concern. Interestingly, the window of opportunity for those innovations may be very short, since it was recognised that a few years beyond the last flooding issues, urgency and awareness on the need for a more novel and long lasting approach to flooding already is fading. This means that the TRC is entering similar emotive territory as issues surrounding water stress, where stakeholders protect rights and ownership of resources (be it water or land) that are being threatened.

In addition, in developing and operationalising the indicators, a core tension of adaptive capacity emerged. The challenge of balancing flexible adaptive solutions and mechanisms at local and user levels with the policy guidance and legal certainty required from higher administrative levels for longer term processes, transpired to be a common issue across the different sectors in both cases. The following section discusses the operationalised determinants of adaptive capacity and details case examples that illuminate their role and importance in adapting to water management challenges in the case areas, as they relate to climate change and variability. It also highlights how the issue of flexibility or predictability relates to each indicator.

Table 12.3 Operationalised indicators of adaptive capacity relating to network components of the governance system with case examples

		Case example	
Network indicators	Operationalisation	Chile	Switzerland
Cooperation (Collaboration)	*Negotiation*: How actors negotiate amongst themselves to resolve water management issues (sectors, actors, government, levels) How actors resolve conflicts, reach agreements on water distribution, security and pollution.	Lack of a formal flexible mechanism of conflict resolution; court costs require resolutions to be financed by the JdV rather than Association of Canalistas, who are financially weaker; user to user negotiation on water issues, and agreements between JdV and mining and hydroelectric companies in the basin; utilities negotiate water prices nodes every 5 years with Superintencia; individualism and autonomy amongst rights holders challenges ability to agree a canal or JdV level strategy or solution and lack of interest to cooperate.	Consultation between private sector (hydropower companies) and commune level; Balance between federal provisions (legal base for financing), individual or group interested stakeholders, and fulfillment of functions concerning security, but also the ecology of the watercourses; lengthy and complex participative settlement of project implementation (leads to weakening of more radical innovation in TRC); conflict resolution expected at commune, with mediation role played by semi-administrative bodes such as Landwirtschaftzentrum; community resource management deemed as an important factor for solidarity and conflict resolution (attempting to foster it despite advances in modern irrigation infrastructure).
	Modes of organisation: How actors collaborate and cooperate across different sectors (public/private), uses (private/private – i.e. hydropower, energy, agriculture, utilities, industry/mining) and scales (local, regional, national, international) – .	Formation of JdV are provided for in the Water Code; Self-organised cooperation between JdV and canals during periods of drought allows flexible agreements and private compensation on water releases from one section to another that helps spread the risk and impacts more evenly and reduce social conflict – based on variable personal relationships and trust (i.e. functions much better between certain sections than others). Drought provision in Water Code instructs	Cross-sector collaboration through the Krisenstab for extreme periods, but little cross-sector co-ordination or contact on water resource management during 'normal' periods; individual company to company or commune to company agreements on water releases for artificial snow production; hydropower operators, universities cooperate and share information and flood management responsibility with canton and commune administrations through the convention for MINERVE;

(continued)

Table 12.3 (continued)

Network indicators	Operationalisation	Case example	
		Chile	Switzerland
	e.g. self-organisation versus legal frameworks that require cooperation.	DGA on compensation and liability, while CNR is guided by Law 18.450 for promotions and financial support of irrigation and efficiency.	water optimisation between hydropower operators (that are reliant on same resource); increasing levels of collaboration between communes (e.g. joint planning and training); sector, regional and local focus to partnerships and platforms for cooperation and joint learning.
	Incentivisation: Mechanisms to incentivise cooperation amongst water stakeholders within a basin (co-ordinating institutions, common visions). Government Subsidies and financing mechanisms inform how higher levels of government interact with and enforce actions at lower levels. Methods of inducing conformity to national, regional or basin priorities: federal/national subsidies, financial support, incentives etc.	Bi-lateral agreements between different sets of rights holders; increasing cooperation between mining sector and farmers (e.g. 10 million peso donation from Mina Andina to JdV, administered by the CNR as the executive and technical body for utilisation of the funds); private financing through water rights owners for maintenance and upkeep of distribution system - users pay for the operation and maintenance of infrastructure, while the state bears cost of the capital investment (Water Law 1981/1123); Government is liable to pay compensation for affectation to 3rd party rights from DGA drought management decisions (i.e. if new wells affect the rights of other owners), and compensate for the costs of extra infrastructure required for water supply.	NFA provides subsidies for increased participation in the implementation of water management projects (including meeting ecological criteria); reliance on financial and technical capacity at federal and canton levels provides for higher levels of cooperation at commune levels (where autonomy and sovereignty is strong); rivalries persist between different communes and the cantons on decision making on watercourse management – but attempts to reconcile them through participative consultation in TRC and final technical implementation signed off by Valais (and Vaud) Council; participative project planning/approval process is resource and time intensive, but aims to foster consensus and cohesion (Hydropower, TRC etc).

	Collaboration: Individual power relations, levels of trust, relative strength of social fibres holding groups together, levels of trust/distrust between parties. Power balances/imbalances affecting cooperation or collaboration. *Nature of support structures*: Compensation, remediation assistance, advice and technical support, financial assistance.	Broken agreements between JdV leads to a lack of trust across upstream and downstream sections of the basin and diminishes the ability to informally manage water sharing, thereby requiring intervention from the DGA; weaker economic actors (including smaller farmers, or those last in the canal) struggle to protect their water rights from quality or quantity damage by stronger economic actors (e.g. mining); negotiations between irrigators and farmers concern increased groundwater exploitation or compensation from drought declaration to pay for constructing more wells; political battle to amend the Water Code was ideological, acrimonious and lengthy for minor changes; general lack of trust between water rights owners community (including DOH) and DGA over Aconcagua Project and well abstraction.	Canton provides financial support for remediation when the communes cannot cover the costs (e.g. 1993); Investment in irrigation infrastructure through both canton and federal subsidies and technical assistance (Landwirtschaftszentrum) and programmes supported by charities at the national level, with the aim of maintaining both built and social infrastructure of the Suonen for social cohesion and conflict resolution; Financial and technical/training assistance provided to communes for water course management and implementation of cantonal provisions (hazard mapping, zoning); collaborative adaptation research projects (Regionprojekt, Verwerktung Markt am Handel) between tourism and agriculture; distrust of canton/ecological sectors and agricultural lobby over land issues in TRC.
Participation	Participation (not just consultation) in the political process, providing a voice in decision-making either directly or through legitimate intermediate institutions that represent their interests.	Water management is effectively in the hands of water rights owners, providing for strength of participation according to the amounts of rights that are owned; civil society participation (as per the IWRM model) is weakly provided for through consultation in the EIA process (or in other basins the Mesa del Agua).	Participative process in TRC implementation (COREPIL) attempted to reconcile different stakeholder positions, but is time and resource intensive and reduces the innovative elements of the project; participation in development and building planning open to organisations (Verbandbeschwerderecht; EIA) and individuals, though in reality may not be implemented.

(continued)

Table 12.3 (continued)

Network indicators	Operationalisation	Case example	
		Chile	Switzerland
Knowledge partnerships	*Integration/Dissemination*: Means of integrating scientific information into decision making, e.g. partnerships with academia and research organisations at national or international level.	Canvassing by means of submission of proposals to DGA to allow greater exploitation of the aquifer; relationship between academic institutions (both major universities and research bodies) is heavily financed by the strongest economic actors; regional and national government agencies rely on technical studies, data and research from major universities and private consultancies (e.g. CEASA water quality studies).	Convention was signed between the owners of the installations, a state university and the Valais for provision of meteorological and climate data for crisis management as part of MINERVE (including informing the public); hydrological data for water course management deemed behind other hazards (e.g. avalanche, rock falls etc); collaborative research between hydrological institutes and hydropower companies to generate short to medium term precipitation prognosis/forecast.
	Exchange & Support: Informal or formal networks to share and exchange best practice, lessons learnt, and technical solutions. Development of understanding, expertise, knowledge sharing, best practise through government support and advisory services.	DOH, CODELCO, CRA, CNR constitute the executive Mesa Tecnica de Agua in Aconcagua, which works with different factors such as regional DGA, MMA, ESVAL, and other State institutions to resolve issues relating to the Aconcagua Project; International experts (EU, World Bank; UN-ECLAC) consulted with and employed by government ministries (MMA, DGA); Influence of foreign scholars (Milton Freedman and the Chicago School[a]) infamous in development of 1980 Constitution; Access to consultants for irrigation projects can be limited for poorer farmers (for CNR proposals); CORFO (corporation of promotion) organises international expeditions to enhance technical capacity of producers (agriculture, industrial etc).	Research partnerships between private companies (hydropower, manufacturing firms) and academia (Technical Institutions, e.g. Luzern, EPFL, WSL, EAWAG) to improve management of surface flows; MINERVE not yet formalised, and paper-based; TRC relies on partnerships with academia for climate change projections; Collaborative sectoral associations (Association of Valais Water Distributers; SDOC/SDRC; Societe Suisse de l'industrie du gaz et d'eau, Swiss Mountain Water) ; WA21 provides an inter-sectoral national level platform for knowledge sharing and dissemination on IWRM across Switzerland; Federal offices are tasked with support and information provision to lower administrative levels; collaborative research projects aim to inform (but not prescribe) decision making (ACQWA; Interegg 3).

Institutional integration (Co-ordination)	*Co-ordination/Clarity*: Level of integration between different water related institutions; Co-ordinating institutions; Relationship between natural and institutional landscape. Clearly defined roles and means of coordination between institutions (e.g. ministries) at different levels of government and different sectors.	Quality (MMA) and quantity (DGA) are managed separately; Rivers are divided up into different independent sections (Aconcagua has 4 sections with 3 JdV) so that delivery of rights are autonomously managed per section; different responsibilities for water spread across the different ministries (mining and hydropower have the money and the power); drought commission was created by the president in conjunction with the drought decree to integrate Interior Ministry, MOP, and Ministry of Agriculture, presided over by the Interior Minister; narrow cooperation between the ministries during 'normal' times; Mesa Tecnica includes JdVs, DOH and CODELCO fully, ESVAL participates intermittently; surface and groundwater managed through different instruments, but the new law improves integration of the two resources through an instrument to improve the infiltration of the aquifers to recover water table levels; land and water rights also separated in law.	Duplication of effort, trying to better coordinate on natural hazard management as challenges mount; Water management at canton level is sector based working group, who are conducting preparatory meetings to establish a Wasserkompetenz Zentrum within the cantonal administration; lack of co-ordination across different sources/uses (springs, groundwater, glacier, surface waters, lateral streams, Rhône); examples of integration of different water management challenges into one institutional/infrastructural response in adaptive actions (e.g. MINERVE, TRC); increasing connection and integration between communes on water supply; Coordination within and across Valais (and also Vaud) for TRC, but not to external stakeholders in the rest of the Basin (Geneva, France); CIPEL provides platform for coordination and collaboration across the different communes and countries sharing the Lac Leman; cross sector coordination through CERISE in water crisis situations; Hydropower teams at commune levels have close relationships with communal organisations.

(continued)

Table 12.3 (continued)

Network indicators	Operationalisation	Case example	
		Chile	Switzerland
	Power & Balance: Institutional power relationships, complexity of institutional relationships; power imbalances/relationships between different sectors/economic groups/ministries.	Media and press articles used to influence decision making on rights allocation and the Aconcagua project; rights administration disagreements between DOH & irrigators and the DGA; power struggles between CNR and MOP, DOH and DGA, DGA and MMA reduces efficacy of coordination and roles – relationship changes from one administration to the next; strength and independence of powerful economic actors, and their infiltration into political, academic and judicial decision making.	Shifting roles and responsibilities across private and public spaces (in agriculture to public and in flood defence to private) according to diminishing and rising capacity; competing policy priorities across sectors (e.g. micro-hydropower versus environmental flows provisions) with no overview or integration into TRC; agricultural and hydropower stakeholders at odds against the ecologicalisation of water management at canton and federal levels; communes are independent and autonomous from canton and federal administrations, but are subject to canton and federal laws, and reliant on subsidies and support.
Levels of decision making	*Administrative Authority*: Relative authority at different administrative levels; level of centralisation or decentralisation.	Centralist government with high degree of Presidential powers and priority setting (e.g. Presidential decision required on projects, drought declaration etc.); Presidential interventions on project approval; regional branches (operational level) of ministries handcuffed by planning and policy decisions by national bodies (political level) and planning offices (MIDEPLAN) in Santiago (seen as 'King'), with lack of effective feedback mechanism between central and regional authorities; Courts have authority to define precedents in the implementation of the Water Code, thereby retain a powerful role in water 'management'; canal and JdV actors express 'powerlessness' against government institutions.	Decentralised system of federalism, with role of implementation at canton level, and in the Valais, the communes are particularly autonomous; subsidies for following ecological and security priorities of the 2001 Federal Directive for watercourse management is key for balancing the autonomy of decision making at the commune level (subsidised up to 95 % for Gefahrenkarte, ZonenPlan, Bauzone etc) enabling canton and federal environmental agencies to ensuring the implementation of priority policies and concepts; canton administrations are responsible for sectoral coordination and support, but communes for implementation, with technical and financial support from canton; Valais, as a relatively poor canton is reliant on federal subsidies.

Agency & Autonomy: Subsidiarity of government institutions; role of private solutions and self-organisation.	Limits to public authorities' ability to actively manage or regulate water resources; state has a subsidiary role in water management, which is in the hands of the private water rights holders; water users have independence and autonomy and the role of denouncing illegal extraction or pollution to the DGA; centralist bureaucracy is sidestepped in rights registration and bypassed by private actor negotiations, agreements and adaptive actions to cope with periods of drought; DGA unable to affect property rights, therefore emphasis is on users to self-organise to resolve drought induced conflicts; in extreme drought periods, government assistance and intervention is at the request of the irrigators.	Federal and cantonal governments have a subsidiary role in water management at the commune level, limiting their authority (right to redress) on water management across the country and region; water decisions reside at the commune public level, but are influenced by canton level coordination and support, particularly in communes where finances or capacity is low; private user groups are gradually morphing into public supported institutions; Increasingly responsibility for maintenance of irrigation infrastructure is shifting to public hand from the private, while canton is taking more oversight over energy concessions; provisions for participation in decision making at local, canton and federal levels take time, but build consensus; Constitutional Right to Petition allows for citizens to self-organise and influence the direction of water management at a federal level.

[a]Klein (2008) and Valdes (1995)

12.6 Synthesis: Commonalities and Linkages Across Indicators

12.6.1 Regime

In the Chilean case, the Water Code is the prime determinant of the administration and management of water, in its incarnation as a water right, rather than a holistic water resource. Furthermore, the Water Code cannot be seen in isolation from the Constitution, in which the private property of water rights are provided for (Article 19.24), guaranteeing the security of these water rights, reducing the ability of legislators to significantly reform the water rights situation and remedy the over-allocation and over-exploitation of water resources in the central and northern basins of Chile, without impinging on constitutionally protected property rights.

Moreover, *regime* is a particularly complicated issue in Chile because of the great influence that the neo-liberal doctrine implemented by the Pinochet regime had and still has on resource management across the country. The rules and regulations concerning water resources should therefore not be analysed in isolation from the changes implemented by the Pinochet regime, which continue to influence resource management in Chile in general. Under the neo-liberal doctrine, water rights were created into a commodity, separate from land, which could be bought and sold as any other commodity. After the new Constitution was crafted and passed in 1980 (the coup took place in 1973), in quick succession, the Water Code was then passed in 1981, the Electricity Act in 1982 and the Mining Code in 1983, each transferring power to the private sector, and de-regulating the governance of natural resources (consumptive water use, non-consumptive water use for energy and minerals for mining). These framework laws have a pervasive effect on almost every aspect of water governance, and every aspect of water resources governance impacts each of the indicators listed in the tables above. The balancing of the exploitative focus of these new laws and tendency to resolve conflicts in favour of stronger economic parties has received attention from other scholars researching the challenges facing water management in Chile (Bauer 2004; Budds 2004; Carruthers 2001). However, this issue has limited relevance in the Aconcagua region, and is more prevalent in the northern and southern areas of Chile, and therefore will not be tackled in this chapter.

The results of the *Regime* indicators, point to a tension between the lack of formality in regulating water resources and the highly formalistic centralised mode of rule setting and policy formation.

The ability of the DGA to have a management role in a basin is extremely limited. The DGA is not allowed to interfere with any third party water rights, once they have already been granted. During times of drought, this is expressly provided for under Art. 314 (Water Code) that states that if *a third party is affected due to declaration of hydrological scarcity, the state is responsible for compensation.* This provision refers to the protection granted to rights holders from negative impacts of decisions taken by the DGA during a declared drought period, specifically the permission for water users to access groundwater to which they do not have permanent

rights. Similarly the weak position of the DGA in enforcing against illegal abstraction highlights the limited ability that the public authorities have to regulate and manage water resources.

Yet, this informality of approach takes place within strict codified rules of water governance. For example in the Junta de Vigilancia for Sect. 2, the process of formally legalising it through the official procedures has been an issue for over a decade due to the inability to resolve the issue of its borders. The mismatch between the institutional structures and the natural structure is the division of river basins into different sections, with weak connection between them. Only in periods of declared drought, have these institutional borders been dismantled (DGA taking over the river, and ignoring the sections of Juntas), as a last resort. Any other form of intervention on the river by the DGA also has to be demanded by water rights owners, in relation to economic, financial or allocation issues. However the DGA's lack of enforcement capability entails a regulation void, in which the certainty water owners cherish according to the Water Code has become meaningless in the basin's reality of over-exploitation and increasing drought periods. The lack of a regulating hand and management capacity from the government side is thus seen by some experts to have detrimental effect on the effectiveness of the water market (Dourojeanni and Jouravlev 1999). The lack of price, and clarity over prices, hampers the market system functioning to meet its goals.

The relationships between the judiciary, legal registries and the political and economic elite in Chile has also received broad attention in other studies (Alvarez 2005; Bauer 2004; Budds 2004; Carruthers 2001) and therefore was not a major focus in the research. However, the relevance of a lack of neutrality and a politicisation of water management decision making does impact the adaptation choices that are presented to the technical bodies responsible for more operational elements of water management in Chile. For example, an interview account detailed the pressure that the Bachelet government had placed on the *Superintendencia de Servicios Sanititarios* to force certain utilities in the north to move to desalination, as there was concern that there was not enough water in these northern basins to meet both domestic and mining demand. Technical managers within the *Superintendencia de Servicios Sanititarios* resisted government pressure, as it was deemed unacceptable to transfer the costs of desalination onto domestic consumers, who would have had to pay 3–4 times more for their water delivery, while the mining companies retained the water rights in the upper watershed, with no guarantees of covering the difference in pricing.

Switzerland has a complex, broad mix of different forms of ownership, responsibility, enforcement and rule setting at different levels of administrative government that provides autonomy at the local level in the Valais to set rules and regulations according to the needs and particularities of the commune. However, there are examples of ordnances and directives, which have yet to be implemented in the Valais, either at canton or commune level. For example, the Federal Ordinance for Drinking Water Provision in Emergency Periods (*Bundesverordnung für Trinkwasserversorgung in Notzeiten*), which proposes an organisational structure to deal with drinking water in any kind of crisis, has yet to be implemented by the

canton. Separate from the hazard maps, the canton is required to develop a water map (*wasserkarte/wasseratlas*), which is yet to be achieved. Viewed in relation to the challenges of implementation discussion in Chap. 5, the challenge of implementing prophylactic planning tools to manage indeterminate hazards is hampered by the lack of enforcement power that higher levels of administration have to enforce the precautions implemented at lower levels (either canton or commune).

In the Valais, the rules and regulations which guide water pricing, provision and use tend to be set in commune or canton level regulations (*reglemente*), conventions, concessions and agreements, which allow for some flexibility in revising rules to adapt to newer challenges. However, the length of hydropower concessions means that windows of opportunity for revision seldom appear. This long term fixed nature of the concessions becomes more critical during periods of higher water scarcity, where concession water may be required to replenish reservoir stocks for domestic consumers (e.g. in times of scarcity, SIB may request EOS (Energie Ouest Suisse) to replenish Lac de Louvie, yet until the concession is renegotiated in 2040, no fixed emergency plan for periods of scarcity can be implemented).

The decentralised form of governance in Switzerland is nevertheless still segregated along sectoral divisions, with coordination across the different sector-specific institutions intermittent and irregular, particularly across the energy, water and environment policy process. Both micro-hydropower and the TRC are policy priorities currently, each with their own relationship to climate change mitigation and adaptation. The volume of micro-hydro planned at the commune level in the Valais, is potentially in conflict with the attempts to enhance the social-ecological features of the Rhône floodplain through the TRC. While implementation for both projects resides at the commune level, the canton has oversight for the TRC while the communes have responsibility for micro-hydro, meaning that there is a lack of oversight or integration across the canton and at federal levels.

12.6.2 Knowledge

The situation in Chile is particularly interesting with regards to knowledge, and highlights many of the contradictions and challenges that characterise the Chilean case. Gaps in data and information in the water market are a key issue across water resources management. As the mantra goes, what you measure you manage, and in the case of the Chilean market, the focus is on data for the market (which itself is lacking), while the void of data on ecosystem impacts of the water market signals the lack of concern for managing the watershed system holistically. The DGA (Desmadryl 2010) has expressed their prioritisation of improving and updating the water information system, not only improving the quality and coverage of data in the system, but creating a more accessible online platform to improve transparency. The CNR has also been tasked to assist in the improvement of rights data, due to the lack of capacity within the DGA. Furthermore, more information on hydrogeological and geophysical studies was also deemed to be necessary to establish and assess

quantity and quality aspects of watersheds. According to the DGA Director, the following issues are priorities: designing and implementing special plans of auditing; action plans at the regional level; training for users' organisations; registration of authorised abstractions (to be able to clarify legal and illegal abstraction points); effective systems of abstraction controls, with the obligation to inform the authority; coordination and training with the public attorney, to develop better control and investigation, in cases of infractions and water theft.

While these policy priorities point to a broadening of the informational focus from within the DGA, further investigation would be needed to ensure that the goals have been translated from intention to implementation. Interviews suggested that across water experts in Chile, technical ability is high (though concerns were raised about technical capacity of the MMA at the regional level) but the challenge resides in the inclusion and matching of the technical capacity with where decision making capacity lies. The focus on improving the state of the water market in Chile rests on improving information and transparency of the market to improve its ability to achieve efficient allocation, rather than improve the range of information and regulations that inform market allocations that would account for a broader set of objectives, including increasing the resilience of the social-ecological systems that are impacted by the water market to adapt to changing hydrology.

Another example of this issue comes from the example of MIDEPLAN, the ministry in which projects are evaluated. MIDEPLAN is unable to evaluate projects from a perspective other than the core mandate and purpose of the institution from which it is being proposed. For example, the DOH can only present projects from an irrigation perspective, the Ministry of Mines from a mining perspective, negating any potential integration of benefits or indeed impacts. The challenge is not the level of expertise in Chile, where hydrologists and engineers have the capacity to calculate ecosystem demands and impacts according to water availability, but the paucity of this information and its linkage to the actual rules of water management are detrimental to the holistic resilience of water management. In certain areas, namely groundwater and ecosystem health, the irregularity of monitoring and absence of a co-ordinated monitoring and observation network has led to a lack of data that erodes the DGA's ability to manage the related water rights, especially to be able to manage the groundwater rights during the declared drought periods, when groundwater is more heavily exploited in the Aconcagua.

In the Chilean case, despite legal provisions to enforce obligations on monitoring and abstraction controls, internal DGA guidelines on declaring restricted areas and provisions that require user associations to be established for both groundwater and surface water (requiring these associations to model and monitor abstraction levels) (see Chap. 8 and Chap. 10), major challenges exist in their enforcement. The lack of measurement of non-market based data, and the gaps in information concerning water rights, are major impediments to the DGA's ability to effectively take control of management during periods of declared drought, when they are expected to be able to do so. In order to be able to mitigate or manage the effects of increased droughts on water rights under climate change conditions, the inability to account for the rights and usage that presently exists is a major limiting factor in the capacity

to adapt. This incompleteness of knowledge is mirrored in the relative weighting of economic and environmental issues in the legislative process. Quality and water management rules are set by analysing the economic implication of the proposed rule on the relevant sectors (agriculture, mining and hydro-electricity). It is the responsibility of the department of economic analysis in the MMA to assess proposed rules (according to the planning standards imposed by the Ministry of Planning – MIDEPLAN) with a social discount rate of 6 %.[1] If the economic costs are measured to be too high (according to the equation used) then the new rule will not be passed by through the political route.

Another facet to the knowledge related challenges in the Chilean case, are the tensions between the legal and technical spheres of knowledge and agency and the political or administrative. One manifestation of this is the impotence of the DGA to mediate issues between rights holders in a basin, and the resulting role of the judiciary in conflict resolution. The judicialisation of environmental management has meant that judges, who lack expertise on hydrological or environmental matters, dictate precedents in water resources management at the watershed or national level. There is a chasm between the level of expertise in political and technical decision making, yet there is an ineffective separation of political from technical matters, that handcuffs and frustrates the operational level, weakening their ability to provide workable solutions to mounting challenges at the basin level.

The positive emergence of a plan to implement a set of environmental courts (proposed in conjunction with the emergence of the MMA out of CONAMA) is also likely to be hampered by capacity constraints in expertise. Such courts could be a vital tool to develop more effective and expedient conflict resolution, particularly in periods of drought. However, a long term effort would be required in training and capacity building within the judiciary for such tribunals to approach water conflicts with a more holistic knowledge of the system characteristics, rather than a shallow formal interpretation of the Water Code, which is overbearingly influenced by economics.

Climate change is being observed across Chile, mainly through the reduction in glaciers and snow pack, which is matched by almost all interviewees recognising that decreasing water availability in the Aconcagua and most regions in central and northern Chile will require improvements in the organisation of water management, the information that informs it, and the ability to settle disputes, in order to avoid mounting conflicts. The DGA recently initiated a glacier monitoring programme; there is a general lack of data that would be required to manage climate change impacts, including water rights information, water availability, riparian ecosystem health; but the integration of climate scenarios into water resources planning, both infrastructure and rights management, within the Aconcagua is currently not taking place. However, across the specific sectors, climate change impact studies have taken place (either by the ministries themselves or academia) and there is an

[1] For comparison the Stern Report used 2%, while Nordhaus used 3% (OECD 1997).

advanced level of information on climate change scenarios at global and regional levels, with associated adaptation options per sector (agriculture, mining, energy etc.). The challenge is to integrate climate change impacts data not only into policy and decision making at basin levels, but also developing adaptation options that move beyond sector specific technological fixes to hydrological changes. Furthermore, develop plans at the basin level that would enable adaptation across the different sectors that could minimise further degradation of the social-ecological system.

The sectoral focus towards climate change impact studies means that the subsidiarity of the environment in climate change adaptation is further reinforced. MMA reports on climate change impacts present technical solutions towards mitigation and adaptation to climate change for other water users (irrigation, energy and water supply sectors), but rarely presents the environmental perspective in terms of how to reduce the negative impacts of climate change on environmental degradation and the potential role that enhancing ecological resilience may have in adaptation choices.

The data sets and monitoring networks available for the Alps are in general far more developed and extensive than in the Andes. Despite criticism that the monitoring network is not as historical, widespread or well-maintained as in other areas of Switzerland, the observational data, perception and awareness of climate change is high. Climate modelling information in the cantonal administration and larger hydropower companies' information is integrated into planning for the TRC and the development of larger hydropower management decisions. However, this is contrasted by lack of integration of climate information across other sectors and at lower administrative levels that provides data on water provision as opposed to information on intense precipitation events.

Where climate information is included at the operational commune level, it is mainly related to increases in intense precipitation and natural hazards, particularly as they relate to the ability to employ water turbines for energy production. As part of the Emergency Plan, required at the commune level, there is a requirement to integrate data on stream flow levels, and their response to precipitation. At present, most of the instruments to enable this level of monitoring are not yet implemented, but it is planned to set up a central database, so that whoever requires the information for decision making in extreme events can easily access it. At present, managers rely on maps that estimate the correlation between precipitation volumes and run off.

The current lack of possibility for cantonal oversight over planning and water related developments (refer to the deeper discussion in Part II) at the commune level is one challenge in developing an integrated and coordinated response to more complex and novel challenges, such as those posed by climate change. The separation of responsibility, data bases and information products across sectoral, administrative[2]

[2] E.g. The canton the groundwater monitoring in the Rhône Valley (Monitoring der Grudnwasservorkommen), but not the monitoring of the springs (Quellen), for which the communes are responsible.

and resource (i.e. surface, groundwater, quality, quantity) lines has developed over many decades, but is seen as a challenge to those trying to prepare the response system to better cope with increase precipitation extremes and related natural hazards. While in policy and management planning, the canton's authority is weak and subsidiary, it does have a supportive role in the organisation of the various monitoring networks (Spring Protection, Quality Monitoring, Groundwater levels) when the communes themselves are unable to fulfil their duty.

One of the main challenges discussed in Part II are those concerning the implementation of legal provisions at local levels, where capacity and expertise are variable. Developing the requisite professional overview and forward looking coordinated response to broader challenges (and related investment decisions) that climate change entails at the local political level, where politicians are often in part time posts, is an on-going challenge that institutes, such as EAWAG, are focussing on. On the other hand, at the technical level, support from federal and cantonal authorities is more prevalent. In the case of the hazard maps, which the communes must generate for their tributaries, the federal government acts as a technical support and the canton acts as a connector between the federal government and the communes. In terms of the Geoplans (*Notfallplanung Hochwasser Kanton Wallis*), the communes are also responsible for implementation of the plan, but rely heavily on informational inputs from special engineering consultancies.

A common thread through the Swiss case was the perception of climate change as a problem for the next generation, something to worry about in 10–20 years' time, but not an issue that needed to be dealt with now. Similarly to the Chilean area, stakeholders live at close proximity to glaciated and snow covered areas, and therefore have observed glacier recession, changes in snow coverage, increasing instability of permafrost and changes in precipitation volumes. Local water managers are well aware that as these changes intensify, discharge into springs will affect volumes available for water supply, but deem it to be a problem that will need to be resolved in either 5–10 or 10–20 years' time. More pressing problems relate to the challenges in balancing rivalries between hydroelectricity and social-ecological demands on waterways, with increasing regulation for ecological flows in competition with the development of micro-hydropower and new pumped storage (particularly as the energy landscape is changed in the aftermath of the Fukushima Daiichi nuclear disaster).

Increased storage capacity and man-made springs are technical options proposed for future management of more extreme climate change, when water supply may no longer meet demand. However, stakeholders, such as farmers and water suppliers, who have always dealt with the relative scarcity in the Valais, suggest that their past experiences and tactics in managing the extremes of low to high precipitation means that they are relatively well prepared for the measures that need to be implemented to manage such extremes. Therefore, while climate change may not explicitly be factored into the planning process across local levels, stakeholders suggest that it subconsciously is part of decision making. Furthermore, heightened awareness of climate related risks in relation to extreme events have a narrow window of opportunity. Managers of the TRC and DSFB note the difficulties in developing the level

of scientific knowledge and understanding of factors that should be taken into account in water resources planning, as the memory of the earlier flooding experiences fade.

At the national and federal level, climate change is explicitly taken into account by the federal administrative bodies for environmental and water issues (FOEN, Water Office) as well as national collaborative platforms such as WA21, leading to attempts to foster cross-sector collaboration (MOUs[3]) to share learning and generate integrated solutions to future challenges in hydropower, watershed management and water infrastructure management. Despite the generally high awareness that climate change will lead to a multitude of heightened challenges, a means of finding holistic inter-linked solutions to the challenges of climate change remains elusive at federal and canton levels.

12.6.3 Networks

Within the Chilean case, the lack of unified management across the basin that limits the potential for integration and coordination across the different sectors was detailed in Chap. 5. The DGA has presented its aim of transitioning towards more unified basin management in order to mitigate the escalation of water resource conflicts, by strengthening organisations at the basin level for increased integration and participation of water stakeholders in watershed management. The uniqueness of the Chilean legal and economic framework for water is deemed to be the major impediment to a more integrated approach, but despite this, there have been attempts at strengthening inter-sectoral and basin cooperation through different user organisations, such as the Junta de Vigilancia (which is legally open to all water owners within a basin, although usually only includes irrigators) and the Mesa del Agua to better coordinate and generate information for enhanced decision making and dispute resolution.

The IWRM basin institutions, the Mesa del Agua, were only piloted in three basins in Chile, with limited effect and agency. But in the Aconcagua, a *Mesa Tecnica de Aconcagua* had been set up to better coordinate the stakeholder groups in favour of the Aconcagua Project. At present it includes the DOH, CODELCO and the CRA (*Confederacion de Regantes de Aconcagua* – Aconcagua Irrigators Confederation). The *Mesa Tecnica* also maintains a dialogue with the DGA, CONAMA, ESVAL, CNR and other state institutions, which are important for disputes relating to the project, but are not regular members of the body.

The coordination of stakeholders with a common interest for the realisation of the Aconcagua Project indicates that increased collaboration across the basin can be realised around a specific project. A more challenging, yet potentially more

[3] MOU between the different partners to create a new form of collaboration rather than another federal department.

rewarding, step would be to develop this platform as neutral territory to negotiate and resolve the 10 year long stand-off surrounding the project, by making it more inclusive and providing an arena for dissemination of scientific studies on the basin. This could potentially overcome the current impasse on the scientific basis for groundwater reserves, where the DGA and DOH (together with the irrigators themselves) both have contradictory studies behind their arguments for exploitation or protection of the groundwater in the basin. The impasse over groundwater availability and the Aconcagua project reflects the levels of distrust between the different administrative bodies, the different sectors and the different upstream and downstream actors within the case area. Irrigators view the DGA as blocking their private adaptation ability by closing the groundwater reserves for new rights, since it has been declared to be beyond sustainable extraction. The lack of trust and agreement on scientific evidence blocks the actors' ability to build opinions from a common basis, leading eventually to a further depletion of increasingly vulnerable scarce resources.

The division of the Aconcagua River into four different sections, with three functioning Junta de Vigilancia (and only two that are legalised) means that during periods of scarcity and drought, upstream rights owners are better positioned to control flows to the rest of the Juntas in the basin. While proportional reduction is negotiated across the basin, in reality the upper rights owners may not follow through on promises. Some irrigators felt an overarching basin organisation would allow a more efficient, expedient and less costly resolution in cases of such power imbalances, not only between different rights holders, but in holding the government agencies to account as well.

Although formal routes of negotiation and conflict resolution can be costly and lengthy, the autonomy of water rights holders means that private negotiation between different actors and actor groups (e.g. Utilities, Mining companies and Junta de Vigilancia, and regional officials) often can replace the more time and resource consuming official routes. However, other studies have also shown that this private bargaining and negotiation can also lead to injustices for the weaker political and economic actors (Alvarez 2005). It also closes the door for other stakeholders to participate in decision making over water resources, to which they may or may not have rights, but an interest in its equitable and sustainable management (i.e. other users of the ecosystem services provided from the watershed, e.g. coastal fishermen, domestic water users, environmental bodies).

Money is an amazing motivator. In both case areas, financial subsidies play an important role in incentivising and enhancing levels of cooperation between different actor groups and levels. In the Chilean case, drought declarations come with levels of both enhanced coordination through the DGA, but also increasing availability of financing for adaptation from the Ministry of Interior (through the DGA). Drought declarations also imply increased liability of the government if third party rights are affected by DGA approval of provisional groundwater abstraction. As climate impacts mount, DGA intervention, according to current rules, would mount. Yet while water rights owners are adverse to increasing levels of government involvement in water management, there is less of an aversion to government money

to finance infrastructure for groundwater exploitation (by the DGA) to cope with lower surface flows and subsidies for water infrastructure including both large scale dams (by the DOH) and smaller farm scale irrigation efficiency improvements (by the CNR).

While subsidies exist for the construction of water infrastructure (Water Code, Art. 1123), operation and maintenance is left in the hands of the irrigators. The state invests in the construction of infrastructure, transferring it to the private rights owners once complete. When the title passes to the farmers on a newly built irrigation project, a financing agreement is put in place so that over 25 years, for example, farmers pay for the infrastructure, and the water rights belong to the farmers themselves. According to interviews at the DOH, a new law is in preparation with respect to enhancing sustainability in such projects. However, in terms of operation and maintenance, many of the water canals in the Aconcagua Basin (particularly some of the longer ones such as the Waddington that stretches over 100 km) have high leakage rates, with irrigators at the end of the line often not receiving any portion of their rights allocation due to evapotranspiration and leakages along the way, reinforcing and heightening the impacts experienced during drought periods.

It is not just financial assistance that can be fruitful in fixing some of the underlying challenges to sustainable water management, but capacity building programmes also can play an important role, as learning networks and knowledge exchange can open up the possibilities of applying lessons learnt from one area for innovative approaches to challenges in another. Capacity programmes run by CORFO provide farmers (as well as other sectors) with the opportunity for foreign travel to learn more about techniques and technologies for specific areas of interest. Within the case areas, one stakeholder referred to such a sponsored trip to France as highlighting for him the value of basin organisations for conflict resolution. This suggests that while national institutions see the value that knowledge exchange can have and the importance of developing learning networks for capacity building, the mechanisms to share and integrate accumulated knowledge are lacking. This leads to a failure to translate new insights from external cases to complex challenges within the basin.

The DGA has committed to strengthening the level of expertise and the range of knowledge in the water user associations and their empowerment for using it in dispute settlement and eventually become stronger partners to the DGA in its own mandate to efficiently manage the distribution of water resources. However, clashes between the authority of different government organisations and the agency and autonomy of rights owners at different levels and sectors are one of the defining challenges in the Chilean case. The public authorities in Chile at the regional level are limited in their ability to actively engage in the management of the resource. The DGA, effectively, can administer the allocation of water rights (according to availability) and record the transference of rights in the market. Water management is thereby transferred to the private sector, and the independence and autonomy that this grants water users is not matched in incentives for enhancing levels of cooperation between them.

Despite the lack of capacity within the DGA for actual water management, it is still expected to take on the management of the basin in the most challenging and contentious periods of extreme drought, to effectively control disputes and finance coping strategies. At the other end of the scale, Chile is not only highly centralised but there is also a low rate of delegation from the Presidential and Ministerial level on water resource related decisions, decisions that might otherwise be taken in the operational rather than political sphere. Infrastructural projects, drought decrees, ministerial committees on irrigation development, changes in quality rules are all taken at minister level if not higher. Information gathered by technocrats inform these, but a number of interviewees at regional or operational levels (in DGA, MMA, DOH) expressed their impotence when informing highly politicised and sector specific decisions on water management issues. This suggests that the informational quality of water related decision making is hampered by the lack of functioning cross scale networks, limiting the ability of the authorities at multiple levels to resolve interlinked and complex problems related to increasing stress on a dwindling resource.

The Swiss case represents an interesting contrast to the Chilean in terms of networks. While it is a highly decentralised governance system, it wrestles with similar challenges in terms of subsidiarity of government role and the autonomy of the communes (rather than private rights owners) that challenge building cohesive, integrative and cooperative solutions for adapting to climate change. Levels of cooperation and collaboration differ depending on the scale and sector. Despite the sectoral and small scale arrangement of water resources management that tests the ability to plan for and implement integrated solutions to more complex problems (i.e. challenges of implementing TRC, addressing scarcity issues across neighbouring communes), there are many examples of partnerships and networks across the region engaging in climate challenges. Often, these partnerships are still sector specific, but at least extend out beyond the commune and canton, for the purposes of sharing best practices, technologies, and learning from the experiences of other areas.

While each commune in the Valais does have autonomy over their own water resource, the independent water suppliers have more recently set up the 'Association valaisanne des distributeurs d'eau (AVDE)' which conducts meetings twice per year (a technical day and a general assembly). One stakeholder highlighted how 'each year we choose a different issue, for example protection zones. We get different specialists from inside and outside the region to come and speak about it to inform all of us who are practically implicated in the issue. There are about 40–50 members, and it is a good place to exchange ideas, and get a better understanding for different issues, come up with solutions'. While the association is voluntary, cantonal representatives also take part. The association also runs training courses specialised in drinking water provision. A similar association exists for utilities (*SSIGE: Societe Suisse de l'industrie du gaz et d'eau*[4]), which meet for seminars once per

[4] http://www.svgw.ch/francais/pagesnav/PO.htm

year, while federal research institutes such as EAWAG collaborate on studies and dissemination with the communes.

The canton agricultural administration (Amt für Strukturverbesserung) also plays a role in encouraging (and subsidising through federal assistance) the maintenance of traditional water management structures at local levels, as a stakeholder explained: 'They are trying to support/encourage the maintenance of these organisations because they assist in the upkeep of the infrastructure/minimise costs at the local level. In the old system, the whole village was implicated in the management of the water and the canals. Whether you took water from the top of the canal or bottom of the canal, you still needed to work the same to maintain it – it fostered a unique solidarity. Grundeigenturm still stay with the land. The canton is providing subsidies to maintain the canals and the geteilschaft'. The canton reduces the increasing financial and capacity burden upon them by fostering flexible conflict resolution mechanisms that are less costly than judicial or administrative routes, while also maintaining responsibilities for the upkeep of traditional infrastructure (that plays an important role during extreme precipitation events as well as the summer irrigation season). The investment projects on the Suonen, however, did not have any impact on reducing water demand.

Despite the examples of cooperation and collaboration, Chap. 5 discussed the challenges of coordination and integration across the Valais for the different facets and scales of water resources management. In direct relation to hazards (climate related or no) the crisis management groups, functioning at the commune level, indicate strong coordination across the different sectors and stakeholders, to ensure that emergency responses to hazards are well-prepared and structured. The TRC represents an attempt to better coordinate horizontally across stakeholder interests and vertically from the federal level to the commune level of implementation. The federal administration is eager to create coherence in hydraulic engineering projects across the country under the 'Loi des Course d'Eau', so that the provisions relating to ecosystem health and integrated risk management may be better adhered to.

The same approach is being taken at the canton level for natural hazards, where a stakeholder explained that 'the idea is to create important synergies across each domain with a relation to natural hazards and create a more uniform approach (technically and financially) to the domain. Currently NH tasks are spread across the DSFB and the DWL. Reorganization would foster an integrated strategy for long term protection, the application of principles of precaution and causality and a uniform concept of safety. It would remove duplication of effort and therefore reduce time and cost inefficiencies. The briefing note is asking the Conseil d'Etat to rethink how the section is organised'. The pressure of more frequent and intense hydrological events has pushed federal and canton levels to better coordinate across institutional boundaries, to differing degrees of success.

The financial incentives provided by the federal government aim to encourage an implementation of the TRC that reflects the legal guidelines in canton and federal legislation. The commune's reliance on subsidies is a key tool of authority for the higher levels of administration, enabling the canton and federal government to craft responses and projects that integrate the more progressive elements of the law that

accounts for social-ecological resilience. Despite the financial incentives, challenges in negotiating the different frames of reference and priorities which stakeholders bring with them to the TRC planning committees, has proved highly contentious and time intensive so far, often to the final detriment of resilience based aspects of the project. Moreover, as in Chile, changing climate is making the government potentially more financially liable, as communes are hit by extreme events, the costs of which they cannot cover. The event in 1993 caused damage that most of the communes were unable to cover, requiring the canton to foot the bill for most of the damage. The Swiss parliament has already started discussing the need for a considerable increase in financial resources for protection against flooding and other natural hazards, likely to increase with climate change[5] (FOEN 2011).

The challenges of coordination across policy frameworks and plans has already been discussed under the *Knowledge* indicators, specifically in relation to the micro-hydropower and environmental protection agendas. But this specific issue also points to the issue of harmonising the competing interests through balanced negotiations and participation. In the case of the TRC, stakeholder participation has not diminished the generation of two competing fronts in the discourse. The field is divided between the agricultural front who are unimpressed with the potential loss of land (losers in the ecologicalisation of water management), and the politico-technical and environmental front who favour heightened protection of the natural environment as a means of boosting social-ecological resilience. While in the past corrections, the technical engineering approach followed a harder path, the fact that softer solutions are being sought in the TRC, means that a new equilibrium has been reached, which is little consolation to those actors losing productive land. Participation provides an arena for these voices to be heard and negotiate, but not necessarily an efficient means of resolving such complex issues in an effective time frame.[6]

Interestingly, these issues suggest a very different form of mismatched authority and agency in the Swiss case than in the Chilean. As a decentralised federalised country, the federal administration may set the framework policies and rules, which water management in the cantons and communes should adhere to, but this is limited to strategic guidance, direction and subsidies, while the communes (with less technical and financial capacity) must maintain priority uses and provide solutions in times of water scarcity. Furthermore, in the Valais, the strong autonomy of the

[5] http://www.news.admin.ch/message/index.html?lang=de&msg-id=41748 (aftermath of 2011 flooding event); http://www.parlament.ch/d/suche/seiten/geschaefte.aspx?gesch_id=20083752 (Parliamentary discussions for financial period 2008–2011).

[6] Refer to the comments from an engineer in the TRC: 'It is difficult because they are defending their interests, but my feeling is that they are not really entering into the dialogue, nor are working towards a compromise. We have proposed compensations to these people, but they don't really want to talk, they just stay defending their alternative proposed solution. The process of trying to reconcile these two different views in the participative process of the TRC takes up a significant amount of time. We are working at the communal level as well to help the process along.'

communes can limit the ability for the canton to give advice, negotiate and coordinate; nevertheless, plans such as the *Plan Generaux d'evacuation des Eaux* are implemented, and the canton provides an important link (e.g. launching studies) between the communes and the federal level.

Examples of shifting responsibilities between the public and private sectors and the different levels of administration point to the limitations of the traditional approach to water management at the lowest possible level in the face of increasingly more complex problems. At the commune level, certain private activities have been transferred to the public realm. For example the management and remediation of extreme weather damage is no longer managed privately, but was seen to not only require the commune structure but even canton level commitment, since the level of remediation work and investment began to exceed the ability of the traditional structures in place to cope with it (e.g. in Baltschieder, which was heavily impacted in 2000, the commune had to take over the clean-up operation, rebuilding the streams and water infrastructure, in conjunction with the canton). This shift in the aftermath of such extreme events has tended to remain post event, and although the traditional associations have stayed in place, their roles are diminished, but fostered and supported by the commune or canton (see above).

In other areas, there has been shift of responsibility from commune to canton. For example, the new hydropower concession will no longer be purely in the commune's authority, but administered through both the communal and cantonal levels. Under the new concession period, not only can communes become shareholders in order to take part of the installation under the commune's ownership, but the concession is reviewed and agreed to by the canton (e.g. to ensure environmental flow requirements, refer to Table A7 and Sect. 5.2). In general, the canton has tended only to intervene in issues pertaining to water provision and hydropower at the commune level when there has been a problem in which the cantonal authority needs to intervene. The increase in oversight at the canton level allows an increase in oversight and implementation of ecosystem provisions, while respecting the strength of communal sovereignty over its resources. It also provides a separate body that can negotiate between rights holders and users in the case of conflicts in the complex negotiation of concession agreements as has been shown to be important in other studies of climate change adaptation (Huntjens et al. 2010).

The value of trust in building cooperation and collaboration for resolving complex water management problems is also relevant in the negotiation of energy concessions. The concessions represent a long-term, multi-generational use rights based relationship between state and private actors, and are the basis of significant investment. Concerns about climate impacts are an important factor that must be taken into account in this relationship. The polarisation of the different interests in the TRC has not necessarily been reflected in the multi-stakeholder negotiation process of concession renegotiation in other areas of Switzerland. For example in Glarus, the inclusion of environmental organisations in the concession negotiation has ensured that ecological factors are considered in the agreement, thereby less recourse

from environmental stakeholders in the aftermath of the agreement and a smoother passage through the approval process. However, this level of negotiation is only possible when all stakeholders are afforded an equal place at the table.

Leadership is an aspect of networks that have been shown in other studies to play a role in driving water management systems to innovate and test out novel approaches (Cook et al. 2011). In Chile, the challenges of trust building across different public and private administrative bodies are in part linked to the issue of the informality and lack of accountability or responsibility for water resources management (as opposed to rights distribution). In the Swiss case, the role of environmental organisations in challenging and changing the debate around water resources management has had an impact in shifting water resources policy and legislation to a more integrative approach.

The organisational leadership prescribed to environmental groups has been reinforced by the linkages between them and prominent administrative figures and technical experts in the cantonal administration in the development of the TRC plan and other areas of innovation in water management at the canton level. However, these networks tend to be weaker and once local user level stakeholders are included (e.g. actor participation in the COREPIL) less knowledge exchange based; and it is at this level that cohesion and collaboration in adaptation approach breaks down. Perhaps, investing in the level and quality of knowledge sharing networks to the user level, instead of bringing the plans to them for consultation, would be a means of establishing more functional networks across the policy-implementation gap.

Further investigation into the role of leadership in developing new techniques and innovation for climate relevant problems in water systems could be well served by techniques such as social network analysis. A better understanding of the role of leadership could also improve our understanding of the area managers and decision makers, might concentrate on to better navigate the bridges and barriers affecting adaptive capacity of water governance. Other studies have investigated the role of policy entrepreneurs[7] (NeWater) in terms of their ability to utilise windows of opportunity to translate novel strategies proposed within shadow networks into more mainstream approaches considered within formal policy arenas. These studies suggest that policy entrepreneurs provide a vital disruptive function in change-resistant institutions, allowing policy change to incrementally lead to institutional change.

[7] http://www.newater.info/index.php?pid=1056 – define policy entrepreneurs as (1) they anticipate windows of opportunity by developing and testing attractive policy alternatives and demonstrating their feasibility; (2) they employ strategies of venue manipulation, venue shopping and/or create new venues to be able to insert new ideas, which have been developed in shadow networks, into formal decision making forums, and (3) they use narratives or other discursive strategies to frame an issue strategically, and by that to attract supporters and justify change.

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