

# The adaptive capacity of institutions in Canada, Argentina, and Chile to droughts and floods

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**Abstract** The increasing evidence of global warming calls on all states to enhance their adaptive capacity to deal with climate change. This paper compares the adaptive capacity of two Canadian provinces, the province of Mendoza, Argentina and the administrative region of Coquimbo, Chile in relation to the vulnerability of farmers to droughts and floods by applying the adaptive capacity wheel (ACW). It concludes that Saskatchewan and Alberta, Canada are particularly weak in terms of double- and triple-loop learning and in developing adaptive capacity in an equitable manner, probably attributable to strong climate scepticism in society and the weak economy. In the developing countries of Chile and Argentina, resources to assist with adaptation are often lacking; in Coquimbo, future learning is precarious because of information deficits in relation to data, memory, trust, and responsiveness; in Mendoza, institutions lack variety (redundancy of programs), resources, and governance processes are inadequately responsive. The paper makes contributions at the

regional level by recommending that specific institutional weaknesses and lack of responsiveness be remedied by adopting appropriate missing instruments (perhaps, for example, water transfer provisions in Mendoza). New findings are made in relation to the dimensions of fair governance and learning capacity in the ACW. While learning capacity was closely linked to the dimension of leadership, the deficit of equity was closely linked to other indicators of fair governance (legitimacy, responsiveness, and accountability).

**Keywords** Adaptive capacity · Institutions · Droughts and floods

## Introduction

Society's institutions are challenged in responding to the changing climate occurring at a faster and more variable rate than before. Increases in frequency and intensity of high temperature extremes, heat waves, and heavy precipitation events resulting in flooding are anticipated (IPCC 2014; McHale and Leurig 2012). Governance, the pattern of managing basic social functions (Lauer et al. 2006), if poorly developed can influence the severity of the impacts of extreme events, making them disasters and thereby reducing the trust of people in government's management capacities (CBC 2005; PP 2007). Institutions (social patterns that provide stability and predictability in determining collective action; Scharpf 1997; laws, policies, norms, rules, and practices with a degree of permanency; Homer-Dixon 1999) are a key aspect of governance and critical in stimulating adaptive capacity as they are rooted in cultural practices, deep-rooted lifestyles, and ideological premises (Gupta and Dellapenna (2009). Given the role that

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governance and institutions play in exacerbating or addressing the vulnerability of society to climate impacts, there is a need to know to what extent institutions operating within the current climate change context encourage or discourage adaptation of society to increasingly uncertain impacts of, for example, droughts and floods (referred to herein as d&f), in order to implement the necessary strategies to improve adaptation of agricultural producers.

This paper presents the integrated results of a study<sup>1</sup> of the adaptive capacity of institutions in Canada, Chile, and Argentina responding to climate variability and change, and in particular to d&f, in respect of agricultural producers in dryland river beds fed by snow and glacier melt. It uses the adaptive capacity wheel (ACW), a qualitative assessment tool, to study and assess the findings of a document analysis of key formal institutions and qualitative semi-structured interviews. This comparative case study allowed for key findings in relation to the dimensions of the ACW of learning, leadership, and fair governance.

### The adaptive capacity wheel

The adaptive capacity wheel (ACW) is a qualitative tool to assess the inherent characteristics of institutions to stimulate the capacity of society to adapt to climate change and offer insight into redesign (Gupta et al. 2010). The ACW has subsequently been applied in numerous case studies (Grothmann et al. 2013; Gupta et al. 2016; Klostermann et al. 2010). The ACW focuses on institutional change, considered crucial for climate change adaptation, and the qualitative aspects of adaptive capacity normally overlooked in quantitative analysis.

There is much literature on the adaptive capacity of institutions although the terminology of the dimensions of adaptive governance and the content of these principles in the literature are by no means consistent. Some authors term them ‘evaluative criteria’ (Ostrom 2011) or even ‘elements’ of adaptive institutions (Mollenkamp and Kastens 2009). The discussion in some cases is generic and applies to institutions in general (Gupta et al. 2010; Gunderson and Holling 2002; Olsson et al. 2006) and in other cases to specific institutions such as water governance (Mollenkamp and Kastens 2009; Huntjens et al. 2012). The ACW (published in Gupta et al. 2016; Klostermann et al. 2010; Fidelman et al. 2016) was chosen for its comprehensiveness in combining these literatures (Gupta et al.

2010) and the fact that it has been developed and tested (see 2.2).

### Adaptive capacity dimensions

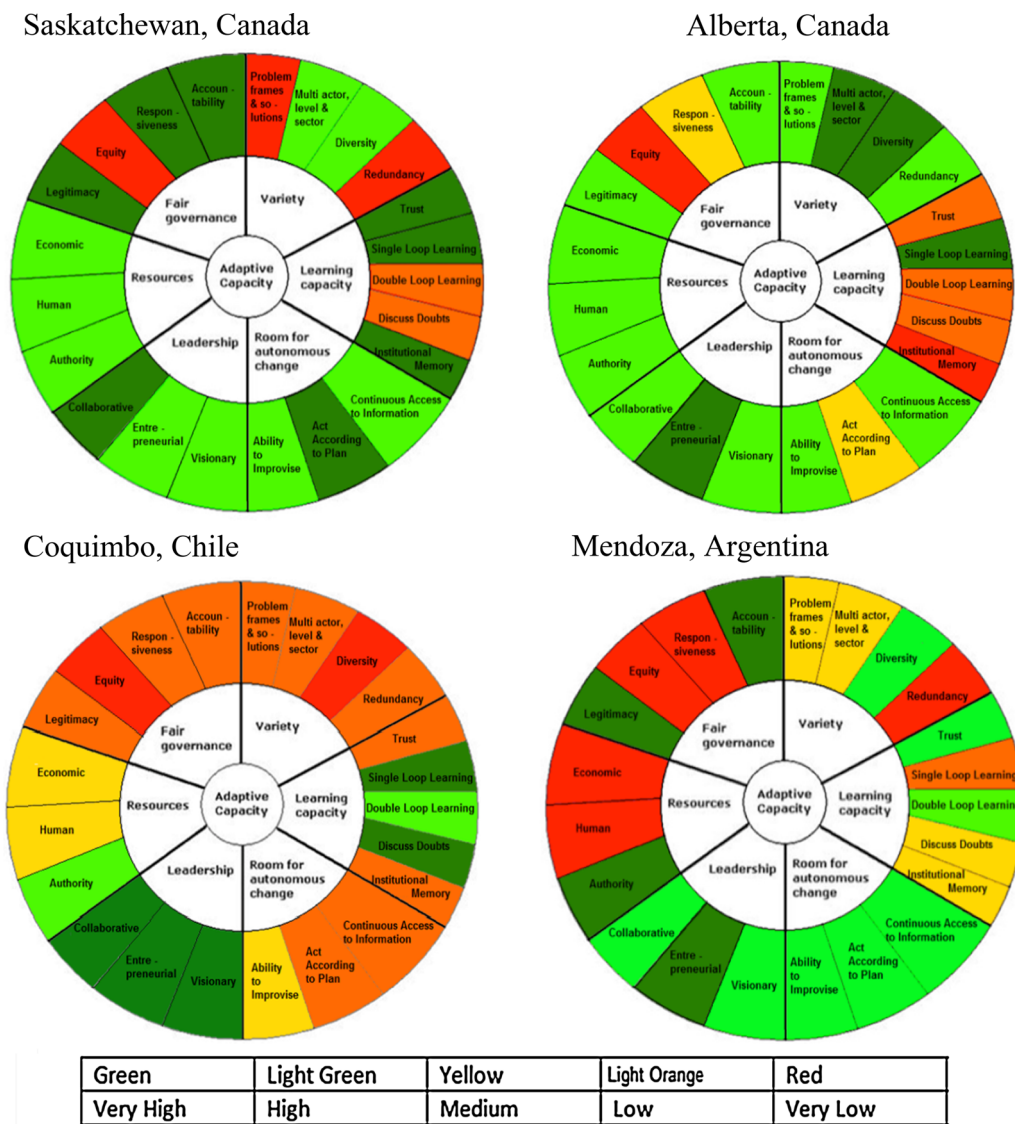
The ACW allows for a comparative assessment of the quality of institutional systems responding to climate variability and change and related d&f in each of the case studies. The six dimensions of adaptive capacity are: variety, learning, room for autonomous change, leadership, resources, and fair governance shown in Fig. 1 and Table 1. A further 22 criteria are indicators of these dimensions and are listed in the outer circle of the figure. Each of the criteria is an indicator of the respective dimension of adaptive capacity shown in the outer circle. For instance, legitimate institutions, displaying equity, that are responsive to change and accountable indicate a system of fair governance. Institutional systems demonstrating strong performance in relation to these dimensions (as further elaborated in the Figure) are more resilient and enhance the adaptive capacity of the system to a greater degree than institutions not demonstrating these dimensions (Gupta et al. 2010).

The ACW was developed based on the literature, field experiences, and brainstorming by researchers as outlined in Gupta et al. (2010). Since development, this tool has been utilized to assess the adaptive capacity of institutions in relation to water, management, civil protection and regional planning (Grothmann et al. 2013), critical energy services during storms (Leon-Camacho et al. 2014), spatial planning, water, agriculture and nature (Gupta et al. 2016), and coastal resource management (Fidelman et al. 2016). This research makes an important contribution by applying it in relation to droughts and floods.

### The adaptive capacity wheel

The ACW is a diagnostic, qualitative assessment tool which has been adapted in this paper to also help to redesign policy instruments and institutions. In this paper, each case study country’s institutional response to climate change and d&f in regards to agricultural producers was assessed using the ACW. The ACW involves a normative judgement wherein the formal institutions and informal institutions are identified (step one) and assessed in two ways: First, in terms of their effectiveness at achieving their stated mandate, and second, in relation to their impact on the assets (including natural, economic, human, social, and technological) of agricultural producers that allow for adaptation to climate change and d&f (Scoones 2009) (step two); they are thereby assessed in relation to the adaptive capacity dimensions (2.2) (step three) and are ranked at an aggregate level (Gupta et al. 2016; Klostermann et al. 2010).

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**Fig. 1** Adaptive capacity wheels (ACWs) for the four case studies

The adaptive capacity dimensions of the institutional system are ranked from very high to very low. Very high green (or darkest grey in black and white figure) ratings reflect institutional structures enhancing adaptive capacity and agricultural producer assets, light green (or dark grey in black and white figure) reflect existing structures but lack of comprehensive informal institutions, yellow (or grey in black and white figure) reflect institutions with no impact, orange (or light grey in black and white figure) reflect institutions with gaps needing to be filled; and red (or lightest grey in black and white figure) reflect institutional structures with obstacles affecting agricultural producer assets negatively (Klostermann et al. 2010). No numbers are allocated in order to avoid the impression of

high accuracy of the rating. Based on this assessment, recommendations are made for policy redesign to improve the adaptive capacity of agricultural producers within each case study.

### Methodology

#### Multi-site comparative case study

This research is a multi-site comparative case study (Bishop 2010) that allows the unpacking and analysis of relationships among mechanisms (instruments responding to climate change and d&f), information, informal

**Table 1** Adaptive capacity dimensions. Source: Adapted from Gupta et al. (2010)

Dimension	Criterion	Definition
1. Variety	Variety of problem frames Multi-actor, multi-level, multi-sector Diversity of solutions Redundancy (duplication)	Variety of policy programs, problem frames and definitions, involvement of many different actors and sectors, with a wide range of overlapping measures
2. Learning	Trust Single loop learning Double loop learning Discuss doubts Institutional memory	Existence of trust, and ability to discuss and debate science, values, norms, that results in changes in practices (single loop), changes in underlying institutional patterns (double loop) or trust, discussion of doubts and institutional memory leading to changes in underlying assumptions of institutional patterns (triple-loop learning)
3. Room for autonomous change	Continuous access to information Act according to plan Capacity to improvise	The existence of and access to information that allows for planning, an ability to act in accordance with plans and still allows flexibility to improvise
4. Leadership	Visionary Entrepreneurial Collaborative	Leadership that is long-term and exercised by different people at the entrepreneurial level, across sectors and governance levels collaboratively
5. Resources	Authority Human resources Financial resources	Resources in order to govern with authority, including having the people and money
6. Fair governance	Legitimacy Equity Responsiveness Accountability	Governance processes that are supported, deemed fair or equitable, responsive and accountable to community

institutions (practices and behaviours), and formal institutions (laws, policies, organizations) (see Pawson and Tilley 1997).

#### *Case study areas*

The four cases were selected based on several factors: diversity of geographical and nation state characteristics (north/south, developing/developed), similar recent and projected exposures to d&f linked to climate change (Sauchyn et al. 2016; Valdez-Pineda et al. 2014; Vicuña et al. 2011), significant irrigated agriculture, and markedly different governance structures. The research sites are river basins in western Canada (Oldman River, Alberta, and Swift Current Creek, Saskatchewan), Chile (Elqui River Basin), and Argentina (Mendoza River). The Canadian, Chilean, and Argentinian river basins represent four large, regional, dryland water basins with significant irrigated agricultural production and similar characteristics (see Appendix I). Climatically sensitive sectors and communities and sensitivity to climate extremes, especially drought

in Canada, Argentina, and Chile, characterize these study areas. Alberta and Saskatchewan are considered the most vulnerable regions in Canada to the expected impacts of projected climate change in respect of water resources (IPCC 2014).

#### *Institutions and content analysis*

This paper builds on a literature review, previous studies by the first author (see Diaz et al. 2009, 2016; Diaz and Warren 2012b; [http://www.parc.ca/research\\_projects-vacea.htm](http://www.parc.ca/research_projects-vacea.htm); <http://www.parc.ca/mcri/>) and secondary sources relating to these study sites. Additionally, a baseline of the existing institutions (formal institutions—organizations, laws, policies, instruments) and informal institutions (behaviours, practices, drivers) relating to climate change and d&f was made. A content analysis of documents describing and establishing the mandate of the formal institutions was conducted. This content analysis explored the themes identified as questions in the interview guide (see Appendix III).

## Interviews

The knowledge and work of key contacts in each country was accessed. The key contacts involved in the previous studies of the first author (see Diaz et al. 2009, 2016; Diaz and Warren 2012b; [http://www.parc.ca/research\\_projects-vacea.htm](http://www.parc.ca/research_projects-vacea.htm); <http://www.parc.ca/mcri/>) in Chile, and Argentina identified key informants (stakeholders and policy personnel) based on qualifications of expertise. Forty-one semi-structured interviews (detailed in Appendix II) were conducted exploring the same themes identified in content analysis utilizing an interview guide (see Appendix III). A pseudonym has been ascribed for each interview to retain confidentiality. The institutional profile and interviews were deductively coded utilizing the dimensions of adaptive capacity outlined in 2.2 and analysed. The ACW for each case study was determined based on the content analysis, interviews, and the normative judgment of the researchers (see Fig. 1).

## Limitations

Limits of normativity exist in ranking each case study's ACW (although the rankings are based on the perceptions of the interviewees), small sample size, as well as generalization. It was very difficult to average some dynamics into one score. For instance, in Chile in respect of 'authority' in relation to resources, the Juntas were found to be very ineffective (Hill 2013; Donoso 2014), but the institutional support of the Chilean irrigation plan was laudatory. Further, economic resources were available for large agricultural producers in all study areas, but not for small or marginalized producers. However, such nuance has been included in the assessment (by reducing the scoring in relation to economic resources (as all producers can't access) as well as allocating lower scores in relation to 'equity').

The analysis of learning was also challenging. Analyzing double-loop learning (the questioning of assumptions and mental models underpinning strategies) and triple-loop learning (a change in understanding in context or a change in world view) (Argyris 1999; Keen et al. 2005) was based on an assessment if a change in worldviews, norms, and practices had occurred, or if social structures had changed. These conclusions were based on the analysis of laws, policies, and instruments, secondary sources, and interviews with key informants. The broad definition of social learning led us to explore aspects in relation to it through questions 2–4 and 6 (which included changes in practices due to extreme events, factors influencing and methods of planning, sharing of information for learning, and change due to new perceptions of stakeholders). The identification of learning in relation to climate change and d&f was based

on researcher observations, not perceptions of the interviewee.

Although interviewees were highly informed key stakeholders in the area, they are not a representative sample. However, we believe that this small sample size is adequate since the primary analysis is of the policy framework in each country.

## Case studies

### *Saskatchewan, Canada*

The province of Saskatchewan shares jurisdiction in relation to agriculture with the federal government but has full jurisdiction in relation to water and property (Hurlbert 2009). Canada is not participating in the Doha Amendment to the Kyoto Protocol which has targets for the period until 2020. It has committed to an economy-wide reduction of 30% of GHG emissions from 2005 levels by 2030 as an Intended Nationally Determined Contribution (INDC) (UNFCCC 2015), but has not yet submitted its final Nationally Determined Contribution. It is not surprising then that Saskatchewan has no provincial measures in this regard.

Droughts are common, but longer more intensive periods of drought punctuated by periods of extreme moisture and flooding are anticipated (Wheaton et al. 2016). A multitude of government, civil society, non-governmental, and private organizations have programs to assist agricultural producers to respond to d&f (see Hurlbert and Gupta 2016; Fletcher et al. 2012). A 'Growing Forward' program alleviates changes in farm income as a result of d&f; government disaster assistance payments help homeowners rebuild after floods; and a host of suasive and managerial instruments assist producers and their communities plan for, and respond to, d&f (Hurlbert and Gupta 2016).

The analysis of Saskatchewan's governance system in respect of agricultural producers, climate change, and response to d&f is depicted in Fig. 1. Starting from the top and moving in a clockwise direction, Saskatchewan lacks instruments relating to climate change and adaptation. Specific instruments respond to d&f and economic stability (see Hurlbert and Gupta 2016; Fletcher et al. 2012). Instruments to address flood are unutilized, building standards and codes do not account for climate change; and a coordinated and integrated drought research and planning programme is lacking at the regional (provincial) and the national level (Hurlbert et al. 2015b). Although there is some diversity of actors across multiple levels of government (in relation to d&f), we feel that the criteria of variety are inadequately met as there is little redundancy.

Saskatchewan institutions have promoted changes in the routines of farm practices (single-loop learning) for



decades (Warren 2016); some double-loop learning has been initiated with irrigation developments in the past. Ranching is only made possible in the dry south-east corner of Saskatchewan due to low-cost, low energy use flood irrigation (Diaz and Warren 2012a). Irrigation technology provided a change in the mental model that viewed the land as wasteland. No current instrument supporting irrigation exists (Diaz and Warren 2012a); however, climate change has led to the closure of some irrigation projects, and concerted planning in response has yet to occur.

A strong agricultural economy has been supported by economic instruments (GS 2013), albeit one dominated increasingly by fewer, but larger agricultural producers. These instruments, as well as strong social capital, create room for autonomous change. The entire suite of instruments (including regulatory instruments surrounding water, management instruments responding to d&f, education and bankruptcy instruments allowing transition to other income generating activities) have supported flexibility in responding to drought (S2, S3).

Leadership is built collaboratively through watershed groups planning for source water protection and improving environmental practices (Hurlbert et al. 2015a). These groups and producers are visionary, strong entrepreneurial leaders (C11). More leadership is required from the government for focusing on the discussion of doubts (scepticism) in relation to climate change and modifying current instruments to account for climate change (S1, C4, C7).

In Canada, governments do have resources albeit there is some atrophy of government budgets, and municipalities (tasked with first response to d&f) have the least resources (S4). Civil society (CSOs) and non-governmental organizations (NGOs) have responded by filling the gaps left by federal government austerity (S1).

Responsiveness or fair governance is challenged. In Canada, equity is a concern as large agricultural producers are the most adaptive having access to economic instruments, information, and technology (S12); the inequality between large and small producers is growing (Statistics Canada 2012).

Table 2 outlines the significant institutional findings that need to be considered in redesigning policies.

The informal institutional practice of climate skepticism (Wyld 2014) needs to be addressed; Saskatchewan people should implement the Paris Agreement and ensure that Canada reduces its GHG emissions by 30 percent of 2005 levels by 2030 (Canada 2015)<sup>2</sup> and the United Nations Convention to Combat Desertification (UNCCD). Reduction in government bureaucracies or finance has left a

deficit in relation to emergency management training, programs for irrigation expansion (S3), and federal long-term water management plans. Most worrying is that the issue of future climate change impacts and deteriorating ecosystem services are scarcely integrated into policy instruments because of the dominant perception of climate and environmental skepticism during the leadership of the last government (FPTGC 2010).

#### *Alberta, Canada*

As is the case in Saskatchewan, Alberta also shares jurisdiction with the federal government surrounding agriculture and shares the programs described in 4.1.1. Alberta has also had a long history of drought and a more extensive history of flooding. Climate change is anticipated to result in increasing the length and intensity of drought and increased rainfall (Barrow 2015). Alberta has more expansive irrigation development, a suite of climate change legislation focusing on carbon capture and storage (EC 2012) to assist Canada's INDC, and a host of water, climate change and adaptation strategies (A7).

Alberta has a high variety score with instruments and institutions responding to climate change and d&f (see Fletcher et al. 2012; Hurlbert and Gupta 2016) and like Saskatchewan has multiple actors at multiple levels. In the past, Alberta developed more irrigated agriculture achieving learning (A5). In a drought of 2001, the ability to temporarily transfer water amongst irrigators allowed significant adaptation and double-loop learning; some irrigators were able to acquire additional water by paying neighbours for their water rights (Morito 2008). Many decades ago in an extremely dry area, the private ownership of land was abandoned and a Special Areas Board was created to allocate grazing rights to the remaining viable farmers and ranchers (Marchildon 2007), an example of triple-loop learning. Flood learning is problematic: floods occur (1995, 2005, 2008, and 2011), reports are prepared, recommendations are made, but no change occurs (A6). The building of dams has also depicted zero-loop learning with intentional marginalization and exclusion of First Nations impacted by the development (Daschuck and Marchildon 2006; Glenn 1999). A site far from the First Nations' land was selected precluding their involvement (ibid.). As a result, a rating of 'orange' has been allocated.

In Alberta, there has been considerable single-loop learning within the space created by instruments for autonomous change. Environmental practices improve soil conditions, economic, natural, and technological capital. Within the water governance system (populated by watershed, environmental, and irrigation groups), many strategies, policies, and initiatives occur evidencing leadership. However, some interviewees identified dwindling trust as a

<sup>2</sup> Canada's previous government had withdrawn from the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).

**Table 2** Institutional findings for case studies

Analysis Unit	Saskatchewan	Alberta	Chile	Argentina
Formal Institutions: Missing instruments	Climate mitigation and adaptation policies Carbon market Inclusive development Irrigation expansion Water transfer, drought policy IWRM Participation UNCCD	Volumetric water charge and return stream flow Inclusive development Participation UNCCD Irrigation expansion Inclusive development Private flood insurance Flood relief for renters, mental health care, resilience disaster planning	Climate mitigation and adaptation Public water right, integrated groundwater regulation, demand water management Emergency planning Building codes, flood zone restrictions Disaster mitigation Ecological goods and services Inclusive development	Climate mitigation and adaptation Efficient water use and irrigation practices Flood insurance Insolvency protection Water transfers Irrigation expansion Environmental stewardship Drought and emergency planning
Unaddressed informal institutional practices	Government austerity Climate Skepticism Ageing infrastructure Growing inequality Deteriorating ecosystems	Government austerity Climate Denial Growing inequality Deteriorating ecosystems	Neoliberal market and colonial elitism Trade liberalization Increasing energy demand Urbanization, population growth Growing inequality Deteriorating ecosystem	Government austerity National monetary policy Trade liberalization Urbanization, population growth Growing inequality Deteriorating ecosystems
Weak adaptive capacity dimensions	Equity Variety Learning capacity	Equity Learning capacity Acting according to plan	Fair governance Variety Learning capacity	Fair governance Variety Resources Learning capacity

result of the employment of multiple, disconnected, singular participation instruments which stymied the ability to act according to plan.

Resources appear sufficient, except in relation to small producers and small businesses specifically in response to d&f. Issues of fair governance and equity exist in the neglect of these individuals in relation to services and disaster compensation, as has been illustrated in the recent High River Flood. Further, federal personnel interviewed were concerned that disaster instruments focus too much on 'security' (disaster from terrorism, not natural causes), a paradigm contrary to resilience, which does not involve participation and inclusive development (C7, C2). Privacy, openness, accountability, and fair governance have suffered negatively impacting access to information and autonomous change.

Climate change denial (Rocher 2013) has limited the opportunities for the expression of doubts and processes that might increase trust. Table 2 presents the formal and informal institutions and identifies areas of weak adaptive capacity dimensions that require improvement.

The most important informal institutional practice that needs to be addressed is climate change and the deterioration of ecosystem services deteriorating producers' natural capital. Special attention to growing inequality, the institutional dimension of inequity, and double- and triple-loop learning are required.

#### *Coquimbo, Chile*

Chile has a strong central government centred in Santiago and appointed representatives administering the 15 regions (one of which is the study region). Water governance is the responsibility of the federal Chilean Directorate General of Water (DGA), but many other entities have mandates in relation to irrigation, sanitation, etc., resulting in a grouping of disassociated regulatory institutions (Romero et al. 2012). Chile has committed to reduce CO<sub>2</sub> emissions by 30% per unit of GDP by 2030 in relation to 2007 levels as an INDC; with international funds, this figure could be as high as 35 to 45% (UNFCCC 2015). Chile has yet to submit its NDC confirming its target.

The private water market in Chile determines institutional water relations (Hurlbert and Diaz 2013). The National Emergency Office of Chile responds to emergencies; earthquakes are the predominant emergency, not drought and flood (Reyes et al. 2009). A declaration of emergency drought has been made in the past several years by the DGA resulting in the local water distributors, the Juntas, reducing water allocations. However, institutional deficiencies and gaps in data make implementation problematic. One interviewee stated that it was better not to have a declaration of drought emergency (even though the conditions of an emergency drought continued to exist) in order to continue to receive financial credit. Adaptation strategies are not accounting for climate forecasts that indicate an increment of temperatures between 3 and 4 °C (Vicuña et al. 2011), desertification, reduced soil capacity (Frene et al. 2014), and reduced water availability (FAO 2011).

Chile's ACW includes both high and low ratings (see Fig. 1). There is a limited variety of problem frames, instruments, and solutions; technology (water diversions) and the market system are prioritized (see OECD 2013; Reyes et al. 2009) reducing redundancy and diversity of instruments. The federal government predominates over all other formal organizations. There are few instruments responding to the uncertain problem of climate change and flood (Hurlbert and Gupta 2016). A disagreement on science, values, and norms prevented one reservoir project from proceeding (Clarvis and Allan 2013).

In the past, strong leadership and the generation of significant resources have resulted in double-loop learning through a combination of water privatization and irrigation policy (Hill 2013). Single-loop learning is also present with new techniques and technologies adopted by producers. However, the neo-liberal market model predominates and no change in assumptions or models inherent in triple-loop learning has emerged. Historic double-loop learning surrounding irrigation and development is at risk of deteriorating into zero-loop learning wherein all learning in relation to irrigation is lost because of the increasing scarcity of water and maladaptation.

Trust is often not present, and doubts are discussed frequently with no resolution; the market and judicial system are accused of 'nepotism' (Hill 2013). Interviewees expressed concern that too much opposition to government could result in another dictator. Powerful interests possessing water rights have much ability for autonomous change and to demonstrate leadership. These groups have resources (Hadarits et al. 2016), but small- and medium-sized producers do not and cannot access programs or markets. Because of this, human and economic resources are ranked as yellow or neutral.

Further, fair governance and equity do not receive high rankings as those with water rights participate in governance and access international and national markets versus the majority of people who cannot. There is a lack of responsiveness as government provides little in the way of a social safety net. At the local community level, collaborative leadership is strong (Reyes et al. 2009); problems are resolved without assistance from other levels of government.

Table 2 assesses the key weaknesses of the institutions in Chile and points in the direction of improved policies, namely that small producers need better access to resources and participatory opportunities; inclusive participatory development instruments are needed which will allow the voices of small marginalized producers to be heard and contribute to resolution of policy problems; and the state needs to engage in trust building and increasing the effectiveness of instruments (such as emergency drought declarations).

It is not clear whether the historic double-loop learning of irrigation development can continue into the future given the weak adaptive capacity dimensions of the Chilean governance system. The inability to access information, lack of institutional memory, trust, and responsiveness stymie the ability of learning capacity and limit problem framing. Many interviewees expressed concern that there was too much reliance on technology to fix problems.

#### *Mendoza, Argentina*

In Argentina, the province of Mendoza has jurisdiction in relation to water and the *Departamento General de Irrigación* (DGI) predominates with staff appointed by the Governor of Mendoza and an assembly of rights holders. An intricate system of water governance includes self-funded riverbed Inspectorates (Mussetta 2013). Water cannot be sold separately from land; thus, it is 'inherent' to land. The federal government responds to disaster, and in Mendoza, the predominant emergency has been a declaration of emergency drought (2010–2014) with inspectors and *tomeros* reducing water proportionally (M3).

There is a deficit of variety as problems of climate change and d&f all lack instruments reducing problem frames and solutions (Mussetta 2013). The province of Mendoza has a history of public engagement tackling issues such as water planning, glacier protection, and integrated land use planning (M1–4). The Argentinian state is largely absent, reducing the number of actors able to provide redundancy and variety. Although there is little activity in Mendoza in relation to climate change policy, Argentina has agreed to reduce GHG emissions by 15% from anticipated business as usual in 2030; this



figure could be as high as 30% with international financing (UNFCCC 2015).

Historic triple-loop learning has created the irrigated oasis (M3) so much so, other drivers such as climate change and d&f are not cognized by the public. This has limited the learning capacity of producers and has historically stymied single-loop learning such as adoption of efficient drip irrigation technology. The Mendocino society is organized around the common cause of ‘beating the desert’ which competes against a sustainable land model (Montana et al. 2005: 5; M5). Expansion of irrigation has occurred (lately in the Uco valley) by large local and foreign enterprises regardless of the consecutive declarations of drought emergency. These large agricultural producers have also adapted to water shortages by using their economic capital to access groundwater by being able to afford electricity for pumping and groundwater licenses.

Triple-loop learning has occurred with the Glacier Protection Act that prevents mining development at the headwaters of the Mendoza River. This law was passed in response to the lobbying of Mendoza producer groups, academics, and environmental groups such as the Popular Water Assembly. Difficulty is experienced with dwindling state resources (M1; Montana and Boninsegna 2016). Nevertheless, strong leadership of government and civil society (including irrigated producers) and room for autonomous change in Mendoza contributed to the triple-loop learning, and collaborative leadership reflected in the passing of the Glacier Protection Law. Conversely, the technology of the irrigated oasis combined with the inherence water instrument that ties water ownership to land has limited autonomous change and entrepreneurial leadership. Producers are unable to modify water delivery based on demand because of the principle that water rights are inherent to the land to which they are allocated; very little change in water practices can result. The fragmented nature of dealing with water has resulted in a deficit in relation to technologies such as capturing rainfall, making better use of groundwater, and fostering the combined use of surface/groundwater (M1).

Resources are strained partly due to government austerity, neo-liberalism, and the neo-colonial state. Large producers have access to resources including economic, technological, and natural capital, but not small ones (M1). As in Chile, these small producers cannot access many government programs. Further, only those with water rights participate in governance and experience responsiveness, accountability, legitimacy, and collaborative leadership.

Table 2 assesses the institutional weaknesses in Mendoza and points towards the opportunities for redesign which include addressing large economic structural issues (national monetary policy, trade liberalization) and their differential impact on small and large producers. The state

could consider adopting instruments promoting efficient water use and irrigation, responding to flood, limited water transfers, and environmental stewardship incentives to create a fairer playing field. Strengthening the ineffective instruments, especially the water inherence principle, would increase the adaptive capacity of rural agricultural producers.

For irrigated producers, water instruments and economic instruments have created a hydraulic society, or one that relies on the dam and irrigation system that created the oasis (Montana et al. 2005). Interviewees believed that this should be recognized, protected in practice, and preserved. However, inclusive participatory discussions on how to address its weaknesses in adapting to climate change and how missing instruments might potentially be introduced, need to occur.

### Comparison—redesign

The analysis of the comparative rankings of each case study using the ACWs is depicted in Fig. 1 and displays some similarities:

1. Significant leadership existed in all case studies. In all case studies, leadership was evident in strong local water and environmental groups. However, leadership of one group alone was not enough to tackle the wicked problem of climate change and d&f and achieve triple-loop learning as was the case in Argentina.
2. Issues of fair governance and specifically equity existed in all case studies. Policies exacerbate the existing vulnerabilities of farmers and lead to increasing inequality in the assets (human, social, economic, technological, and natural) of the small/subsistence producers and large/multi-national producers. Small- and medium-sized producers in Chile and Argentina had reduced access to markets; those without water rights were not allowed to participate in water governance. Coincidentally, in all case studies, participatory instruments were missing to authentically, regularly, and inclusively engage with people in relation to climate change, d&f, and development.

The ACWs also portray significant differences:

1. A high score on ‘variety’ in Alberta resulted in a high score in most other dimensions. Alberta’s water property regime includes both regulatory and market instruments, and an entire suite of instruments exist in relation to climate change and d&f. This could correlate to the high score in relation to ‘resources’ at both the provincial and community level. None of

the three remaining case studies ranked as high as Alberta in either variety or resources.

2. Argentina, where the highest learning score occurred, had the lowest scores in human and economic resources. The rigid instruments (the inherence principle of water) combined with the national financial instability are the contextual variables responsible for generating these scores. The triple-loop learning in relation to the Glacier Preservation Law is both contextual (the importance of the irrigated oasis to Mendoza) and a result of the leadership of provincial Mendoza politicians and civil society (including agricultural producers, environmental groups, and academics). Higher scores for responsiveness, multi-actor/level/sector, and diversity of solutions also exist.
3. Argentina and Chile had lower scores in relation to resources, fair governance, and variety. This ranking is consistent with institutional weaknesses: in Chile the weak local government; in Argentina the monetary difficulties. It also reflects the significant barriers faced by small- and medium-sized producers in trade, and the inability of those without water interests to participate in water governance.

The ACWs display weaknesses of institutional systems: In Saskatchewan, there are concerns surrounding resources (both economic and human) especially at the municipal level. Responsiveness and institutional memory are also issues. In Chile, where the water market exists, both a full suite of economic instruments for agricultural producers as well as instruments respecting climate change are not in existence. As a result, there are significant low rankings. In Argentina, problems of redundancy and problem framing exist. Lastly, in Alberta, considerable issues exist surrounding learning and accountability of management instruments. The colour coding allows for the introduction of missing instruments (identified in each case study) to buttress the low adaptive capacity dimensions' ratings.

The ACW was a useful heuristic tool for evaluating and comparing the institutional dimensions of adaptive capacity. This method allowed a deep institutional analysis (2.3) to be summarized in a manner allowing ease of communication and comparison of results, while still retaining nuance in descriptive reporting.

## Conclusions

This research assessed the institutions responding to climate change and d&f in four case study areas, Saskatchewan, Canada, Alberta, Canada, Coquimbo, Chile, Mendoza, and Argentina, and utilized the ACW to qualitatively assess and summarize the findings. A thorough

review of secondary sources and several previous studies within the areas was supplemented with 41 additional semi-structured interviews.

The ACWs for each case study illustrated the strengths and weaknesses of the institutional systems and allows for a comparative analysis that uncovers new findings of the relationships between the dimensions of adaptive capacity. Although Chile and Argentina are challenged by lack of resources and informal institutional practices of colonial elitism, Mendoza, Argentina, displayed the most recent example of triple-loop learning passing its Glacier Preservation Law and both countries had significant irrigated agriculture displaying double-loop learning. The leadership scores were high in all case studies (especially entrepreneurial), but the Mendoza, Argentina, case study displayed an interesting strength of agricultural producers, environmental groups, and academics allowing triple-loop learning.

Focussing on just one adaptive capacity dimension (such as variety) may not also increase other rankings. Alberta had the greatest variety, but learning was problematic, especially in relation to flood. Numerous reports and studies are prepared after each flood, but very few recommendations are implemented. The greatest learning (triple loop) found in Mendoza, Argentina, did not coincide with a high ranking of variety or resources, but instead collaborative, visionary leadership, responsiveness, multi-actor/level/sector, and diversity of solutions. This study discovered that focusing on leadership at all levels is important for social learning.

The identification of areas receiving low scores and problematic adaptive dimensions are important at the regional level in order for changes to be made in institutions. Addressing institutional weaknesses in the case studies should proceed in a manner appropriate for the context of the case study. In Argentina, the adoption of a water market may not be culturally acceptable or appropriate (Hurlbert and Mussetta 2016). However, incremental flexibility introduced to the water inherence system in limited circumstances might be advantageous as it could allow for changes in water demand management (transferring temporarily or permanently water to another property or crop) facilitating better adaptation to water shortages. The illustration of weak dimensions of the ACW is important at a regional level in order to develop strategy for improvement.

The biggest deficit identified in relation to fair governance in all case studies was equity. The growing spread between small/subsistence producers and large/multi-national producers is occurring and driven by increasing trade liberalization, government austerity, and growing income inequality. Large agricultural producers in Alberta and Saskatchewan have more access to economic and

technological assets to facilitate adaptation. Within the developing countries of Chile and Argentina, equity is exacerbated by neo-colonial practices preventing all producers' equal access to markets. Although local water practices countered this in all case studies, there is a risk that these institutional practices will be lost. In Chile, these informal practices are not contained within the constitutional water market laws and require recognition by a formal instrument. In Argentina, the formal inheritance water instrument governing surface water is being avoided by large economically powerful agricultural producers through groundwater licensing. In Alberta, Canada, the water transfer mechanism is recognized as a formal instrument but has not been used in a decade. A complementary formal instrument of inclusive participatory development to improve the indicators of fair governance (legitimacy, responsiveness, and accountability) is required in all case study areas. The context of the case studies depicts how the indicators of fair governance are inter-related, whereas the learning capacity described above was related to leadership.

The INDCs of the case study countries evidence an intention to mitigate in response to climate change (UNFCCC 2015). Although the developing countries' targets are set in a manner allowing continued economic growth, with international financial contributions, significant reductions in the percentages of emissions can be made. The Canadian case study data were collected during the term of a conservative government; the election of Justin Trudeau in October 2015 is hopefully a harbinger of a new era. Hopefully, this era addresses the deficits of the adaptive capacity of the Canadian governance system as well as recognizes that resources must be provided to developing countries in order to address climate change within the framework of the United Nations Framework Convention on Climate Change.

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