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A Comparison of drought instruments and livelihood capitals* Combining Livelihood and Institutional Analyses to Study Drought Policy Instruments

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ABSTRACT

Institutional analysis is used to assess macro (in)formal policy approaches while livelihoods analyses takes a micro bottom up approach to analyse how livelihoods can be improved. The two approaches are rarely linked and scarcely applied to the understudied problem of drought. Hence this paper addresses the question: How can the livelihoods approach be combined with institutional analysis and how can such a hybrid method be applied to assess policy instruments aimed at improving, for example, the resilience of agricultural producers to drought? This paper designs a methodology and tests it in three case studies on drought in Alberta (Canada), Coquimbo (Chile), and Mendoza (Argentina). The methodology requires (a) identifying policy instruments (regulatory, market, suasive, and management), and assessing their effectiveness in addressing the (b) local to global drivers of the problem being addressed while (c) improving the resilience of people through contributing to livelihood capitals. The paper concludes first, that different policy mixes are necessary in different geographical areas and circumstances for enhancing livelihood capitals, and second, that it is possible and useful to combine top down institutional analysis with bottom up livelihood capitals.

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1. Introduction

Climate change may lead to more intense and frequent droughts and floods (IPCC, 2014). These impacts, together with expanding (urban) populations and increasing industrial and agricultural demands on water, will increasingly stress the already precarious water resource (Cleaver, 2013) while exacerbating people's vulnerabilities (Sauchyn, Diaz, & Kulshreshtha, 2010).

Drought, one of the least understood and most ignored disasters, seriously affects agricultural communities and local to global food security (Cleaver, 2013; Li, Gupta, & van Dijk, 2013; Mwinjaka, Gupta, & Bresser, 2010) with huge damage (Sheffield & Wood, 2011). Meteorologists define drought in terms of precipitation shortages, agriculturists refer to crop water stress, and hydrologists to surface and subsurface water supply. This paper defines drought socio-economically, i.e. where water resource systems fail to meet the demands of farmers and their communities (Diaz, Hurlbert, & Warren, 2016). In Canada the 2001–2 drought resulted in a USD 5.8 billion drop in GDP and the loss of 41,000 jobs (Wheaton, Kulshreshtha, & Wittrock, 2010, p. 280). Drought impacts are acute in agricultural communities where livelihoods depend on natural systems and are projected to increase.

Most agricultural producers have experience in adapting to dry conditions or drought, however, the future intensity and duration of such conditions are anticipated to challenge their adaptive capacity (IPCC, 2014). Given forecasts that predict exposures exceeding previous experience, prudent policy-makers will endeavour to enhance adaptive resources and coping strategies. Adaptation reduces long-term vulnerability to climatic variability and change (IPCC, 2012) and coping involves people acting within existing resources and ranges of expectation to mitigate shocks or stresses on livelihoods (Opiyo, Wasonga, Nyangito, Schilling, & Munang, 2015).

The limited drought research focuses either on institutional approaches or on bottom-up livelihoods studies. The two approaches are seldom combined. Hence this paper addresses the question: How can livelihoods and institutional analysis methods be combined to identify the best policy instruments for improving the resilience of agricultural producers in responding to extreme events of drought? And what instruments build livelihood capitals? It develops a methodology and tests it in drought prone Alberta in Canada, Mendoza in Argentina, and Coquimbo in Chile (Magrin et al., 2014; Sauchyn et al., 2010). It first discusses livelihood capitals (see 2), institutional analysis and a hybrid methodology (see 3), applies this to the case study regions (see 4) before drawing conclusions (see 5).

2. Methodology

2.1. On livelihoods and capitals

Resilience is characterized by a robust system that persists when confronted with shocks or disturbances (Folke, 2006). A robust community innovates when faced with fast or slow complex changes by drawing on institutional memory to recombine processes and structures, find new ways of doing things, renewing systems and self-organization (ibid.). Individual and household resilience is influenced by factors enhancing or constraining their livelihood prospects (Moser, 2009). Constraints can include destruction or damage to assets (homes, businesses, etc.), lack of access to assets, and the psychological effects of deprivation and exclusion (Moser, 2009). It can be exacerbated by demographic characteristics including (lack of) education, and gender, age, ethnicity and cultural norms which affects livelihood options, behaviour and expectations (Banks, 2016; Van der Land & Hummel, 2013).

Enhancements or constraints are ‘determinants of adaptive capacity’ (IPCC, 2001, pp. 895–897) and contribute to the ability of individuals, households, and social systems to build resilience. The determinants are different forms of capital or assets (including stores, resources, claims, access and property rights (Chambers & Conway, 1992)) that are required for sustainable livelihoods (Quandt, 2018), in different proportions and combinations that people use to adapt to change and build greater resilience (Moser, 2009; Moser & Satterthwaite, 2008). In reviewing the literature on climate risk management, disaster risk reduction, climate change adaptation, community-based adaptation, and capital-based vulnerability and adaptation, Moser (2009; 1998) determined that all of these approaches rely on access to livelihood capitals, a focus developed in the 1990s by the British Department for International Development (DFID, 1997). These capitals have generally fallen into the categories of natural, financial/economic, human, social, and physical (Quandt, 2018).

For agricultural producers (e.g. dry land farmers, irrigators, and livestock producers), ‘physical’ capital includes infrastructure, tangible assets such as livestock, equipment (e.g. for drip irrigation), tools or drought resistant seeds (de Haan, 2000) (although others like Scoones (1998) classify this under financial capital);¹ human capital includes knowledge, education, experience, skills and health;² financial capital includes money, savings, state transfers, remittances, physical farm size, pensions, bank credit and loans (Erenstein, Hellin, & Chandna, 2010); natural capital includes biodiversity (e.g. pollinators) and ecosystem services such as soil, minerals, wetlands, water resources, or forests (de Haan, 2000; de Haan & Zoomer, 2005); and social capital includes access to relationships, formal and informal networks, and public/private services which can accentuate financial capital and human capital (Glaeser, 2001; Portes, 1998). The capitals are mobilized in livelihood activities supporting strategies to decrease vulnerability and are shaped by the institutions (Scoones, 2009).

Some capitals overlap (e.g. natural capital generates financial capital) (Quandt, 2018); complement others (e.g. financial capital allows agricultural producers to purchase physical capital such as machinery); diminish others (e.g. school fees increase

human capital but diminish financial capital) (Huai, 2016; Quandt, 2018); enhance resilience (e.g. through strong bonding relations in social capital); and increase vulnerability (e.g. when physical capital has not accounted for diminished natural capital, e.g. reduction of water in rivers and dams) (Huai, 2016). Hence, merely increasing capital may not reduce vulnerability (Huai, 2016).

2.2. On institutional analysis methodology

Livelihoods are affected by institutions at multiple levels of governance. Institutions are patterns of behaviour grounded in norms and values (Homer-Dixon, 1999), and develop, protect and create access to the capitals of individuals and households (de Haan & Zoomer, 2005). Institutions range from customary behavioural patterns (assisting neighbours during drought) to formal policies (e.g. disaster relief policy), and laws (e.g. legislation, regulations) (Helmke & Levitsky, 2003; North, 1989) and include policy instruments governments use to attain their goals to shape behaviour (Anderson, 2010, p. 242; Gupta, van der Grijp, & Kuik, 2013; Howlett, 2011).

Policy instruments can be regulatory (command and control rules with penalties for default (Baldwin, Cave, & Lodge, 2011) such as environmental standards, water use permits and impact assessments); financial such as carbon taxes, subsidies and grants (Stavins, 2003); voluntary (suasive) instruments such as awareness building and education (Rivera, 2002); and managerial instruments where local people, governments, non-government organizations (NGOs), and private organizations individually or jointly manage a resource or problem (Gupta et al., 2013).

Institutional analysis generally focuses at higher levels of analysis. It requires an understanding of the drivers of a problem, the policies developed to address the problem, the specific instruments adopted, how these instruments change the behaviour of actors given the drivers to achieve specific ends, and hence, how the instruments can be improved (Young, 2005). Although it focuses on how it changes behaviour, it has not actually looked at the impacts on the livelihood capitals of people.

2.3 Hybrid method development

Hence, this research combines micro livelihood analysis with more macro, top-down institutional analysis. This requires the context specific identification of the (a) drivers/causes of a problem (e.g. drought), (b) the global to local institutions (organizations, laws and policies) addressing the problem (e.g. growing demand, climate change), and (c) the specific regulatory, market, suasive or managerial instruments used to change behaviour (e.g. water use permits, water markets). (d) Instruments are evaluated as (-) ineffective (not advancing their mandate), (+) moderately effective, (moderately advancing the mandate) or effective (++) (achieving the mandate), and (nd) where there was no data in respect of achieving the instrument’s mandate. (e) After considering the effectiveness of the instrument in achieving its mandate, the instrument was ranked as (+++) strong, (++) medium strength, (+) some

strength, or (-) less strong in terms of enhancing the livelihood capitals of the targeted local people. Based on the analysis of which instrument works and under what conditions, the results are assessed and recommendations for redesign of instruments are made. In undertaking the assessments, the method relies on content analysis, literature and interviews.

2.4 Hybrid method application

This hybrid method was applied in our three case studies selected based on similarity in increasing exposure to drought, and the fact that they are dryland agricultural river basins with significant irrigation (Sauchyn & Santibanez, 2010).³ In Mendoza, located in the Argentinian Eastern Andes, the Mendoza river basin has irrigated agriculture, fruits, horticulture, cattle, and goats and has experienced droughts in 1968, 2011–2015. In the Western Andes, the Elqui River Basin in Chile similarly produces irrigated agriculture, pulses, forage, vegetables and cattle and has experienced droughts in 1998, 2001–2002, and 2010–2015. In the South Saskatchewan River Basin of Southern Alberta production consists of irrigated agriculture, pulses, forage, vegetables and cattle and experienced droughts in 1998, 2001–2002, and 2011 (Hurlbert, 2018).

We combined a literature review of drivers and instruments relevant for drought,⁴ content analysis of policies, and more than 500 semi-structured interviews in three different projects⁵ and 41 interviews with key relevant policy stakeholders (19 in Canada, 8 in Alberta, 7 in Coquimbo, and 7 in Mendoza). Unlike research developing objective frameworks of socioeconomic variables from large datasets as indicators of livelihood capitals in a community (see Li et al., 2017; Quandt, 2018), this research explores qualitative measures using peoples' perceptions, and subjective measures of resilience (Jones & Tanner, 2015) which is best for ascertaining resilience (Fang, Zhu, Qiu, & Zhao, 2018) and allows for historical memory and learning (Huai, 2016).

3. Case study Findings and analysis

3.1. Drivers and context

The common causes of drought related vulnerability for agricultural producers in the case study areas include government austerity, growing inequality, changing demographics (population growth and urbanization), aging agricultural producers, shortages of farm labour, state governments prioritizing the economy over the environment, diminishing biodiversity and ecosystem services, and climate variability and change.

Specific to Argentina and Chile is the driver of trade restriction, where only very large producers sell internationally and nationally (Hadarits, Santibanez, & Pittman, 2016; Montana & Boninsegna, 2016). Most producers sell locally or to larger producers (ibid) and cannot scale up because of high credit costs and exchange rate risks (e.g. in Mendoza). Producers lack government support, cannot afford risk insurance, or cannot access government tax relief because they are in arrears of their water payments (ibid.). Local governments with limited tax revenues can scarcely finance emergency aid, welfare, and relief for poor communities.⁶

3.2. Drought instruments

Table 1 classifies drought instruments as addressing a) climate change and water management/conservation, and b) drought or lack of moisture. The latter are prioritized here, but previous research (see footnote iii and iv) addressed the former (Diaz et al., 2016; Hurlbert, 2018). Table 2 identifies the instruments in the case study areas. Instrument effectiveness is scored in the right column, based on interviews. Some instruments focus on protecting the water (e.g. conservation, water quality reports, glacier protection), some on access to water (e.g. inheritance or land ownership brings water ownership, licenses for water use), some on enhancing income (e.g. water markets and trading, proportional water reductions), and some on improving resilience (e.g. income stabilization, crop insurance, drought forecasts). Alberta in Canada (an industrialized country (IC)) has the most instruments but few aimed at small or poor producers, no formal water rationing systems, and no glacier protection instruments), while Argentina and Chile (the developing countries (DCs)) had the least with few suasive instruments and some management instruments in Chile.

3.3. Effectiveness of instruments at achieving mandate of the instruments

Given the driver of government austerity, regulatory instruments requiring substantial government resources were poorly financed, manned and enforced; this meant that fines for illegal water extraction, enforcement tools of water reduction quotas, and instruments to effect reversion of water licenses were not fully used. The Latin American practice of '*turno*,' or proportional water reductions to meet drought conditions, was effective in reducing water allocations, but not in enhancing adaptation to consecutive years of drought, and resulted in maladaptation. An emergency drought declaration had been declared for five consecutive years in Elqui, Chile (2010–2015), and four in Mendoza, Argentina (2011–2015). Interviewees stated that informal institutional practices implemented by water administrators allocated water differently from the formal legal water rights system and lacked accountability and transparency. Adaptive practices such as changing crop locations, sharing water with others, or permanently or temporarily transferring water were not achievable because of the rigid and mandatory *turno* reduction provisions.

Agricultural producers in Canada found economic instruments (such as income stabilization programmes and crop insurance) useful for droughts not exceeding two years, but expected that longer droughts would require different instruments. Small producers in all study regions found crop insurance too expensive and in the DCs small producers often couldn't qualify for economic instruments because of unpaid taxes and/or water fees or other requirements. Tax forgiveness was the most frequent agricultural disaster assistance option in Argentina (DACC, 2014); in Chile it was small emergency funds of USD 300 per family (Reyes, Salas, Schwartz, & Espinoza, 2009). DC interviewees saw the small producer programmes as too little too late (see also Reyes et al., 2009) or as keeping small unprofitable producers in business.

Table 1. Classifications and description of instruments to cope with drought.

| Instrument | Description | Climate change/Water Management/ Conservation | Drought/ Lack of Moisture |
|---------------------|--|--|--|
| Regulatory | Adopted by state authority; Binding; Determining what is permitted and what is not; Includes sanctions for non-compliance; Without a market component | Emission reduction requirements; Water quantity and quality standards (Sterner, 2003); human right to water and sanitation services; Environmental liability, standards, bans, permits, quotas; Environmental impact assessments; Fines for illegal water extraction; Land use restrictions (UNCCD, 2013); Emergency measures; Planning requirements; Waste water treatment controls; water ownership rules and rights | Licence quotas for water allocations and permits; Holdback for minimum river flow; Reclamation of unused water allocations; Water rationing |
| Economic/ Market | Encourage behaviour through market signals; Direct programme spending; Investment in ecosystem management; Financial incentives – Subsidies, taxes (Henstra, 2015; Stavins, 2003) | Funding adaptation and mitigation research; Water tariffs, taxes or charges; Tradable permits/rights to water (Garrido & Gomez-Ramos, 2009); Payments for ecosystem services (UNCCD, 2013); Export measures encouraging virtual water export; Subsidies, loans equity, bonds, crowd financing | Crop insurance; Loan instruments (Botterill & Chapman, 2009); Grants and subsidies for new technology |
| Suasive | Measures on environmental awareness and responsibility (OECD, 1994); Public and private information, research and public awareness; demonstration by government of behaviours in government asset management and procurement practices (Henstra, 2015) | Knowledge generation, mobilization, dissemination; Education and training; Aggregate indices; Networks or associations; Drinking water quality reports and alerts; Provision of information to public; Agricultural producer infrastructure grants; Instruments to provide access to new technology, e.g. new seeds resistant to excessive drought | Drinking water quality reports and alerts; Provision of information to public; Drought prediction and alerts; Instruments to provide access to new technology, e.g. new seeds resistant to excessive drought |
| Managerial | Includes mostly self-management by private actors but could be hybrid management processes | Water attaching to land and managed by owners as common property; Demand management of water; Source water protection plans; Local water governance; Long term water management on integrated basis | Insolvency Drought strategy or plan Environmental best practices |

Source: Adapted from Gupta et al., 2013, p. 45; Hurlbert, 2018; the references in the Table include those that are additional to those from the two main source documents.

Suasive instruments were effective in providing information and persuading; drought forecasts and drinking water quality reports effectively changed people's behaviour. Some interviewees believed that Glacier Protection policies were ineffective as they do not address the root causes of climate change; however, this policy in Argentina prevented glacier contamination by mining.

Generally, water managerial instruments were effective at their specific level to achieve their specific purposes. Local watershed groups in Canada were effective at planning source water protection plans. Irrigated associations were efficient at managing water interest allocation within irrigation districts. However, integrated water management instruments were ineffective as development decisions and integrated land management decisions were made outside of the water sector. In Alberta integrated land planning and source water planning had occurred with extensive public consultation, however, each in a disconnected silo orchestrated by government.

3.4. The effectiveness of combinations of instruments

Interviewees often discussed not just single instruments but their interconnectedness. Two instrument combinations were particularly relevant: one on governing water, and the other on the financial viability (financial capital) of agricultural producers.

1) Instruments governing access and allocation of water

During drought, the instruments determining access to and allocation of the property interest in water are particularly germane.

Each case study region combines instruments (see Table 3) to build resilience (a finding consistent with Gupta et al., 2010). Alberta uses many water instruments while Chile and Argentina allocate water through the market or inheritance principle, and have few additional instruments. In Alberta, a government regulated water system is supplemented with the ability to transfer water interests in certain circumstances in designated basins where the water resource is fully allocated. Licenses and markets enabled maximum production in the 2001–2002 drought of Alberta (Corkal, Morito, & Rojas, 2016). When an upcoming drought was identified, the government regulated water system communicated expected shortages, and the water market allowed short term transfers among water rights holders. Some irrigated producers transferred their water interest to others for compensation and also accessed financial instruments including crop insurance and income stabilization programmes. This allowed the transferees to grow a crop that would otherwise have been impossible (ibid.) building the financial capital of agricultural producers with and without crops.

In contrast, in Chile, where the water market is the predominant water governance mechanism the market is effective (Hadjigeorgalis, 2004) while inefficient (Hadjigeorgalis & Iriquelme, 2002) unsatisfactory and inequitable (Reyes et al., 2009). Market interests dominate the 'public' nature of water, leaving poor rural communities, *Campesinos*, and small agricultural producers in a precarious, vulnerable position (ibid.). This situation is similar in Argentina where water ownership inherent in land (the principle of 'inheritance') and established a centuries old oasis in the middle

Table 2. Instruments responding to climate change and drought.

| Inst | | Water / Climate change | Eff | Drought/ Lack of Moisture | Eff |
|------------------------------|-----|--|---------------------------------|--|-----|
| Regulatory | All | Environmental liability | - | | |
| | | Water pollution control/ Water quality standards | + | | |
| | | Waste water treatment controls | + | | |
| | | Land use restrictions | | | |
| | Can | Emergency measures planning requirements | - | Licence quotas for water allocations/permits | + |
| | | GHG reductions (industry,sector specific) | - | | |
| | LA | Glacier Preservation Law (Ar) | + | Water rationing (Turno) | - |
| | | Fines for illegal water extraction (Co) | - | Zero Net Land Degradation target of UNCCD (Ar) | - |
| | | Reversion of unused water allocations (Co) | - | Ecological flow restriction (Co) | - |
| | | Fee for non-use (Ar) | - | | |
| Inherence water instrument | | - | | | |
| Energy efficiency | | - | | | |
| Economic | All | Public participation in environment (Ar) | + | | |
| | | | | Crop insurance | ++ |
| | Can | Tradable rights to water (Al) | + | Loan instruments | + |
| | | Water tariffs | + | Agri-income stability programmes | + |
| | | Carbon offset market (Al) | - | Ag producer water infrastructure grants (FRWIP) | + |
| | | | | Agri-innovate fund to provide new technology and global market competitiveness | n.d |
| | LA | Tradable rights to water (Co) | - | Grants irrigation efficiency (Al) | + |
| | | Water tariffs (Ar) | - | Micro insurance | - |
| | | Export measures encouraging virtual water export (Co) | + | GEF projects (Ar) | - |
| | | Carbon offset markets (Ar) FAO | + | Provision of supply of inputs as relief measures | - |
| TeleFund and Trust Fund (Ar) | | n.d | Fee for non-use of water (Co) | - | |
| | | | Drinking water subsidy for poor | + | |
| Suasive | All | Drinking water quality reports and alerts | + | Provision of information to public | + |
| | | Provision of information to public | + | | |
| | | Agri-Environmental programmes | + | | |
| | | UNFCCC State communications | | | |
| | Can | Sustainable Development goals | | | |
| | | FSP for environmental best practices | + | Drought prediction and alerts | + |
| | LA | Climate change plan (Al) | + | Drinking water quality reports/ alerts | + |
| | | National climate change plan | + | GEF and CDM projects (Ar) | n.d |
| | | Adaptation plan (Co) | - | Tariff rebate on building wells (Ar) | - |
| | | Glacier Protection policy (Co) | - | INDAP outreach (Co) | - |
| Management | All | National strategy integrated water management (Co) | + | | |
| | | Water attaching to land and managed by owners as common property | + | Hyogo Framework for Action | + |
| | Can | Local water governance (irrigation) | + | International Standards | + |
| | | Source water protection plans (Al) | + | Risk management tools | |
| | | Boundary Water Treaty | + | Insolvency | + |
| | | Integrated water plan (Al) | - | Drought strategy (Al) | + |
| | LA | | | Integrated land use management and planning | - |
| | | | | Public participation in water strategy, planning (Al) | - |
| | | | | Local watershed plans | - |
| | | | | National irrigation policy (Co) | + |
| | | Public participation (Ar) | + | | |

Legend: (-) ineffective (+) moderately effective (some indication) (++) secondary literature and interviews confirm (nd) no data

of the desert (Montana, Torres, Abraham, Torres, & Pastor, 2005), but in today's strained circumstances of emergency drought declarations, it is limiting (Hurlbert & Musetta, 2016). This principle when combined with forced 'turno,' create a rigid, non-adaptive water governance regime. After four years of emergency declarations the water system is rendered a supply side managed system unable to transfer water to high value crops, meet emergency plant requirements, or restrict water use for urban gardens in favour of agricultural production (ibid.) restricting agricultural producers' financial capital.

2) Economic instruments

During drought, agricultural losses can be minimized through instruments that stabilize income including crop insurance, farm disaster loans, or compensation. All case study countries had instrument mixes. Two mixes are important: those facilitating irrigation, and those allowing for livelihood transitions.

Financial instruments (and corresponding management instruments) built irrigated agriculture in Alberta and Chile. In relation to livelihood transitions, a full suite of instruments in Canada in relation to bankruptcy and insolvency and personal exemptions from creditors allow for a transition for insolvent agricultural producers to another livelihood. These instruments are absent in Chile and Argentina.

3.5. Effect of instruments on livelihood capitals

Many instruments identified as effective contributed favourably to different livelihood capitals (see Tables 4–5). A discussion of each individual capital follows.

Human capital

All studied areas had drought warning, prediction and alert systems that educated agricultural producers. Table 6 shows the

Table 3. Water governance instruments and institutions.

| Study area/ Principle | Alberta | Chile | Argentina |
|----------------------------|--|--|---|
| Governing water principle | Most beneficial use | Public good, but right of access is private; property/marketable commodity | Public good |
| Allocation of water rights | Licensed interests with some ability to transfer in certain circumstances | Initially by government; then market | Inherent with land |
| Water Priorities | Statutorily legislated model with some water trading | None | Human use, irrigation, industry, then fishing and plant ponds |
| Dispute mechanism | Government minister, then court litigation | Court of law and local <i>Juntas de Vigilancia</i> | <i>Tomero</i> , Inspector, then Appeals Council |
| Pricing | Regulated by Utilities Commission | One off fee for access right, then service costs; market sets price on transfer | Regulated by government body |
| Regulatory | Regulatory system overseen by Environment and Sustainable Resource Development department | Absent after initial allocation | Regulatory system overseen by General Department of Irrigation (DGI) |
| Market Management | Water market enshrined in Chilean constitution Local watershed councils develop source protection plans | Limited transfer provided by legislation Basin organizations and water tables exist to integrate water management | Absent Water is managed by DGI, General Users Assembly, Riverbed Inspectorates |

unaddressed drivers included aging producers and farm labour availability. According to interviewees, in Canada labour laws (e.g. migrant worker legislation) inadequately addressed this while such laws were absent in Chile and Argentina.

Although we did not review educational and health services, in Canada disaster relief instruments address mental health (including stress) impacts by contracting the Red Cross to provide counselling and basic needs in times of disaster, albeit drought has never qualified for this type of relief. Moreover, the 'Farm Stress Line', provides 24 h counselling services for agricultural producers needing immediate assistance. Such services to contribute to human capital, were not available in the DCs.

In Chile during drought, local water committees would form and obtain drinking water delivered by truck. However, the water quality and quantity were limited. Municipalities also provided this service in Argentina, but local communities generally relied on groundwater wells if they didn't have access to the river water.

Social capital

In agricultural communities, social capital is created through instruments aiming at developing and governing irrigation

Table 4. Financial instruments of agricultural producers.

| Study area/ Principle | Alberta | Chile | Argentina |
|--|---------|--------------------------------------|-----------|
| Farm Income Stability Programmes | Yes | No | No |
| Farm Water Infrastructure Programmes | Yes | Irrigation infrastructure programmes | |
| Agricultural Loans | Yes | Yes | Yes |
| Crop Insurance | Yes | Yes | Yes |
| Specialized Programmes for Small Farms | No | Yes | Yes |
| Bankruptcy Discharge | Yes | No | No |

Table 5. Impact of instruments on capitals.

| Study area/Capitals | Alta | Chile | Argentina |
|---|------|-------|-----------|
| Human | ++ | - | no data |
| Social | ++ | + | ++ |
| Econ. | + | + | - |
| Techn. | + | +++ | - |
| Natural | - | - | - |
| +++ Strong ++ Medium Strength + Some Strength - Less Strength | | | |

associations, producer associations or producer cooperatives, and at supporting local watershed groups.

In case study areas associations made policies on irrigation. In Argentina, irrigation associations, producing strong social capital, are organized through local *tomeros* and inspectors. Inspectors are appointed by, and report to, the water governance organizations (DGI). Large agricultural producers belong to large associations, and have stronger links with the DGI, government authorities and personnel, financial institutions, and suppliers. However, as producers become smaller their associations reduce in size, and links with external entities weaken (Hurlbert, Musetta, & Ivars, 2015). Moreover, only people holding land with water rights attached (and water fees fully paid) may participate in this water governance system, thus excluding those without water rights; the same exclusion exists in Chile. Hence access to associations and resulting social capital is distributed unequally.

While local watershed support and producer association instruments also formally exist in Chile, they are often ineffective due to lack of trust and conflict between private water rights holders (Clarvis & Allan, 2013; Reyes et al., 2009); in Argentina large irrigated agricultural producers access water rights and groundwater in the mountains through a surreptitious ground water license market that only large producers with substantial foreign capital can afford (Hurlbert & Musetta, 2016). In Alberta, water has been fully allocated and there is no expansion of irrigation.

In the DCs producer associations or cooperatives are critical for agricultural producers to access and exchange information, and link with other organizations as described above. These associations operate at a higher level than individual irrigation districts and vary by the economic size of the producer. In Canada, producer associations exist, but membership is not determined by size of agricultural producer but by type of produce, e.g. the breed of livestock, or type of dryland crop (Corkal et al., 2016; Warren, 2013), and are less important for social capital.

However, in Canada watershed groups have more importance than in the DCs. All countries had instruments at some point promoting local watershed planning. However, while in the DCs this occurred only once, and the instrument was discontinued (Musetta, 2013; Reyes et al., 2009), in Canada, the instrument had a long-term deployment, and plans were

Table 6. Unaddressed drivers and missing instruments.

| Case Study | Missing drivers | Missing instruments |
|------------|--|---|
| All | Climate change, drought, deteriorating ecosystem services Priority of economy over environment Growing inequality Demand for energy Government austerity Urbanization, population growth, aging producers shortage of farm labour | Pervasive GHG reduction, Berlin Rules on Water Resources, Human right to water and sanitation, Climate change 2 degree limit, Climate change lawsuits, Right to be free from climate change damage, Fines for illegal drainage Payments for ecosystem services, conservation tenders, environmental taxes, bonds, royalties, tax rebates, conservation auctions Direct programme spending on research on climate change mitigation and adaptation Subsidies on products or practices, loans, equity, bonds, crowd-financing and grants, Climate Impact assessments, Adaptation Fund, Development market place, Strategic climate fund, Emissions trading and transaction log (UNFCCCC) Creation on non-farm employment opportunities Payment for ecological services (shelter belts) Flood insurance, Hazards of place indicators of vulnerability, Catastrophic bonds Climate change forums, Measures on climate change and environmental awareness and responsibility DRR tools, indicators, best practices to build resilience Government demonstration through practices of procurement, building infrastructure, and processes of environmental stewardship/climate change mitigation Persuasion for water demand management UN Watercourses Convention, UNECE Water Convention Long term water management plans on integrated basis, Proactive community planning for water shortages, Demand management of water, Integrated water resource management Community disaster planning for resilience Indicators – Hyogo Framework – Hazards of Place DRR tools, Long term counselling support services post flood disaster Inclusive participatory development |
| Can | Climate change denial, scepticism Increasing size of farms | Regulatory water rationing Zero net land degradation Irrigation development policy Glacier protection |
| LA | Increasing trade liberalization Neoliberal market and colonial elitism Private social support system and lack of transparency (Ch) Price/currency fluctuations (Ar) | Emergency measures planning requirements, Hyogo platform at local level Flood provisions Disaster financial assistance, loans Water infrastructure grants, innovation grants Insolvency Drought strategy |

NB. All (All Countries), Can (Canada) LA (Latin America), Al (Alberta), Ch (Coquimbo, Chile), Ar (Mendoza, Argentina)

made, assessed, revisited, and iteratively re-employed. Overall, watershed groups and their participatory planning exercises united agricultural producers, local governments, stakeholders, and the public. Participatory instruments in Mendoza effectively engaged academics, CSOs, NGOs, government representatives, agricultural producers, and scientists to discuss issues from water planning to the Glacier Protection Act enabling increased social capital.

Financial capital

All study regions had similar economic instruments enhancing financial capital: crop insurance, emergency drought relief (discussed above), and infrastructure upgrade programmes. The two instrument mixes in 3.4 above contributed to financial capital. Three trends were noted: (a) small agricultural producers (like *Campesinos* in Argentina and Chile) faced difficulties accessing economic instruments like loans to purchase water or equipment (thereby constraining small producer financial, technological, and natural capital), even though policymakers wanted to support them; (b) Large agricultural production could leverage all instruments (e.g. crop insurance, water transfer) and take advantage of unaddressed drivers (migration to urban centres, aging agricultural producers etc.), to optimize technologies, and to mitigate economic and climatic risk (Hadarits et al., 2016; Hurlbert & Musetta, 2016; Valdez-Pineda et al., 2014); and (c) there is a growing gap between small and large agricultural producers through barriers to trade, access to local and international markets, and low ability to diversify into

both producing grapes and making wine especially in the DCs (Montana & Boninsegna, 2016).

While DC policies counteract such trends through emergency relief for small producers, informal social water practices at the local *tomero* water agent level (Argentina), and the inheritance principle protecting small water rights holders even when they don't pay fees (Argentina). Those without water rights, the goat herders or *Campesinos* in Argentina and Chile are negatively impacted during drought as their human rights and indigenous rights to water are not recognized; even dam building arguably beneficial for agricultural producers increases their vulnerability by reducing the seasonal runoff that might have increased grass for livestock grazing (Montana et al., 2005).

Physical capital

Growing inequality between large and small producers affects access to physical capital. In Canada large agricultural producers use state-of-the-art business and agricultural practices including GPS driven farm equipment, modern seeds (with various pesticides and herbicides applied directly to seeds), and cropping practices (like reduced tillage techniques). In Chile, large agricultural producers can benefit from financial capital, irrigation development and private water market expanding the viticulture and horticulture export industry, although in Mendoza the uptake of sophisticated technology is slower (Montana & Boninsegna, 2016).

In Canada dryland farmers had historically constructed 'dugouts' to retain and hold rain and runoff in anticipation

for dry seasons on their land. Community infrastructure received very little support. Technology supporting flood or excess moisture was engineered within a completely different sector than infrastructure for water retention for drought. There were few if any instruments planning for drought found in this aspect of physical capital.

Natural capital

Agricultural producers in all study areas wanted to preserve the natural capital (soil, water, etc.). Suasive instruments including drought predictions, advance meteorological information, and basic drought information enabled producers to proactively respond and plant drought resistant crops and change herbicide and pesticide applications. In Canada, environmental best practices were adopted to protect water quality (such as moving cattle out of source water), prevent erosion, and maintain water infrastructure (dugouts, riparian areas, etc.). Managerial instruments (local watershed groups engaging in source water protection planning and group environmental farm planning conducted by neighbours) also encouraged these practices. In addition to enhancing financial capital, these instruments also enhanced the resilience of natural capital and social capital through agricultural producer and public participation. There was a deficit overall of effective instruments valuing ecosystem services and restoring wetlands with consequent diminishing of ecosystem services (FPTGC, 2010; Herzog, Martinez, Jorgensen, & Tiessen, 2011).

Instruments not only shape capitals, capitals shape instruments. For example in Chile irrigation instruments failed because of a lack of trust and conflict between private water rights holders (Clarvis & Allan, 2013).

4. Conclusions and redesign of instruments

This study provides several insights. First, in relation to methodology: combining the institutional analysis method with livelihood capitals enables a more fine-tuned analysis of how policy instruments influence the different capitals of local people and how these can be improved to enhance their resilience. It shows that different instruments influence different capitals, the net effect may not always be positive and that instruments mixes are needed to address the different capitals.

Second, the case studies show that (a) instruments are best used in combination: combining regulatory water instruments (e.g. water licenses, disaster relief) with market (temporary water transfer; income stabilization), suasive (e.g. drought predictions and alerts) and management instruments (local water groups planning for source water protection) to enhance physical capital (e.g. irrigated agricultural base), social capital (e.g. participatory instruments), financial capital (e.g. crop insurance), human capital (e.g. through awareness campaigns) and natural capital (e.g. low tillage technology). Resilience improves if all livelihood capitals and their interrelations are accounted for. (b) Instruments need to address all drivers of the problem of drought if they are to have structural impact (see Table 6). If the drivers of growing international trade at the cost of the environment (WEF, 2013, p. 11) and climate change are not addressed, drought cannot be addressed structurally. (c) Failure to consider instruments holistically may result in

maladaptation. For example, energy subsidies encouraged groundwater pumping enhancing the economic capital of farmers at the cost of falling groundwater levels or reduced natural capital. (d) At the same time, some instruments need to be prioritized, such as the right to water, e.g. in Coquimbo, Chile, which have been marginalized through instruments encouraging water markets and by producers like mining companies, hydropower installations, and large agricultural producers who have gained water rights for next to nothing and protect their rights in courts to the detriment of others (Larrain, 2014). In Mendoza, water for human needs (drinking water and sanitation) is prioritized, but *Campesinos* are excluded from this. *Campesinos* assert their rights to water living in the arid desert making a subsistence living without water access and without ability to participate in the extensive water governance institutional system. The case study regions could learn from others regarding instruments currently not used (e.g. insolvency, home quarter protection), but which could enable better resilience (see Table 6). Ideally the selection of appropriate missing instruments should be made in a participatory manner in order to choose local, culturally appropriate instruments (Hurlbert, 2018).

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Notes

1. Excluded from this study were items such as transportation, roads, distance to nearest town (Quandt, 2018).
2. Excluded from this research were considerations of ability to work, nutrition, labour power, female literacy, and immunizations (Quandt, 2018).
3. This research was made possible by researchers participating in the "Vulnerability to Climate Extremes in the Americas" project (see <http://www.parc.ca/vacea/>) the International Research Initiative on Adaptation to Climate Change (IRIACC) funded by the International Development Research Centre (IDRC), the Social Sciences and Humanities Research Council of Canada (SSHRC) and the Natural Sciences and Engineering Research Council of Canada (NSERC).
4. A review of journal articles studying drought as well as literature of non-governmental organizations (e.g. FAO) was undertaken to compile a list of drought instruments and facilitate their identification within the study areas.
5. These are: (1) SSHRC (Social Science Research Council of Canada) funded collaborative project between Canadian and Chilean researchers focused on institutional adaptations to climate change (IACC) (see <http://www.parc.ca/mcri/>) (268 interviews in Canada, and 86 interviews in Chile assessing the vulnerability and adaptive capacity of local agricultural producers; 100 Governance interviews in Canada and 30 in Chile). (2) Deliberative democracy in the watershed project funded by SSHRC (see www.parc.ca/vacea/index.php/water-governance) (100 Local water advisory group interviews). (3) Vulnerability to Climate Extremes project funded by SSHRC, NSERC, and IDRC, with case studies in Canada, Chile, Argentina, Columbia and Brazil (see <http://www.parc.ca/>)

vacea/) (100 Agricultural producer vulnerability interviews; 70 governance interviews).

- Although Canadian producers don't endure the same restrictions on sale of their produce, they do experience the same constraints regarding local governments.



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