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Creating resilient water governance for irrigated producers in Mendoza, Argentina

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ABSTRACT

This research explores the institutional water governance system of irrigated agricultural producers in Mendoza, Argentina in the context of a changing climate (predominantly increasing events of drought and water scarcity). An assessment is made of the impact of water governance instruments on producers using the methodology of vulnerability and adaptive capacity. Analysis focuses on the impact of the institutional water governance system on the adaptive capacity of producers' resources, or capitals (human, social, economic, technological, and natural). Conclusions and suggestions for improving the resiliency of agricultural producers and increasing the adaptive dimensions of Mendoza's water governance system are made based on this analysis.

1. Introduction

1.1. Impacts of climate change

The community of Mendoza, Argentina (depicted in Fig. 1) is a desert oasis developed through intensive, artificially irrigated diversified agriculture (viticulture, horticulture and fruit production). It is a fragmented territory: 96% of the population and activities are in the irrigated area (4% of the provincial territory) situated in or near the capital city of Mendoza. A web of medium and small sized towns spread over agricultural lands away from Mendoza (Montana and Boninsegna, 2015). Scattered goat breeders (local Aboriginal communities descendants of huarpes) are 4% of the population and populate the other 96% of the lands that is non-irrigated desert.

The main water source is the glacier and snow melt fed Mendoza river. Extreme drought has been experienced in Mendoza in 2010–2014 (General Department of Irrigation (DGI), 2015) and 1966–1970 (Prieto et al., 2010). Long term climate change predictions are for an increase of between 2.5 and 3 °C and a reduction in snowfall and runoff of between 10 and 15%, but an increase in summer precipitation of about 30% (ibid.; Boninsegna and Villalba, 2006a,b). The impacts of climate change are anticipated to be a water deficit increase and potential compromise of oasis survival (Montana and Boninsegna, 2015). There has been a cyclical decrease in water availability and an accentuation of extreme events such as hail, solar radiation, frost, exacerbating already typical problems of dry lands.

1.2. Concepts and theoretical framework

Institutions are an important determinant of the ability of a community to adapt to future climate change impacts and current climate variability (Willems and Baumert, 2003). Institutions can either advance the adaptation of the community and its members (constituting "institutional capital" see below) or hinder adaptation by preventing adaptive actions. The institutional governance system, or the pattern of dealing with basic social functions (Lauer et al., 2006), is an important component of the adaptive capacity and vulnerability (IPCC, 2001: 893–897) of agricultural producers (Hurlbert and Diaz, 2013), as are the resources or assets which agricultural producers have access to in order to build their livelihoods (Moser and Satterthwaite, 2008). Fig. 2 lists these resources based on what the IPCC calls "the determinants of adaptive capacity" (IPCC, 2001: 893). Access and control of these resources are important to reduce vulnerabilities, but it is the capabilities of actors to organize them into adaptive activities that

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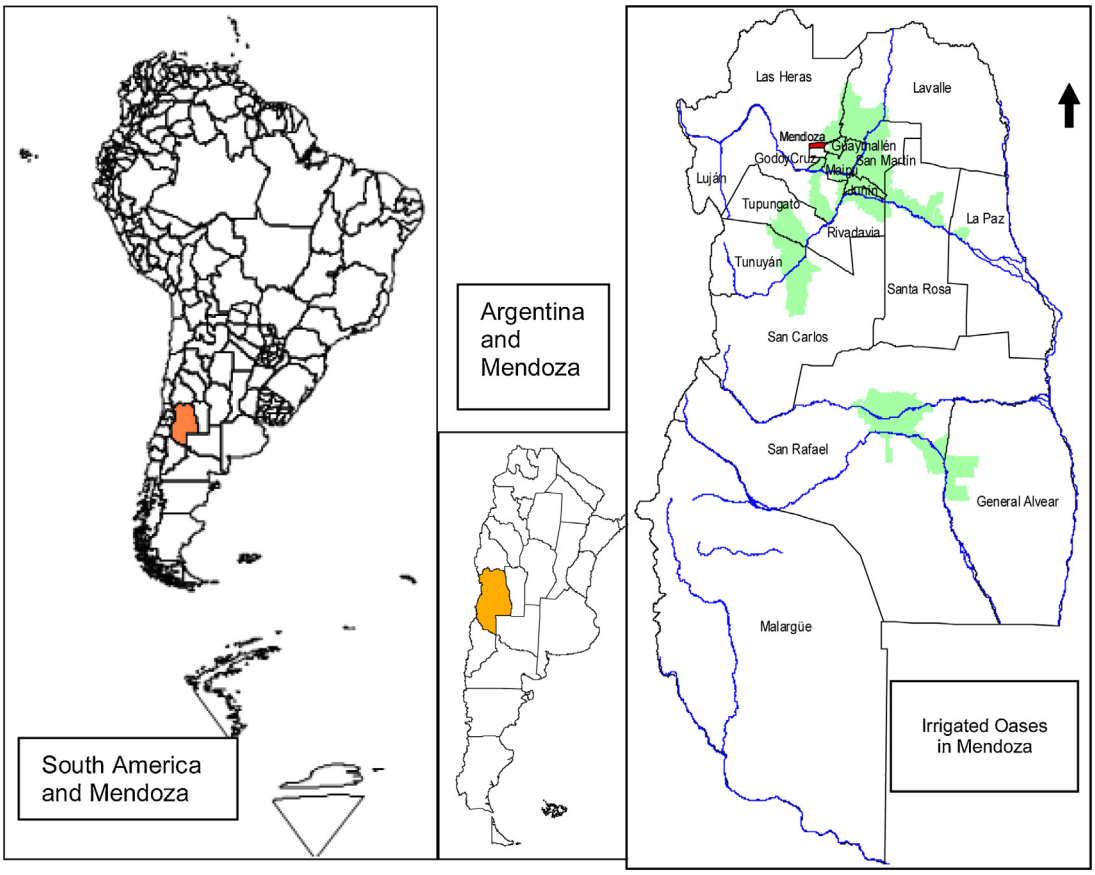

Fig. 1. Mendoza, Argentina.

defines the balance between sensitivity (determined by lack of or limited resources), and adaptation (defined by the existence of resources that could be mobilized to reduce sensitivity).

These determinants of adaptive capacity appear on Table 1.

Institutional capital exists within the context of governance and it is the researchers' hypothesis that adaptive governance facilitates institutional capital, which in turn facilitates other capitals on Table 1. Governance, water governance, and adaptive governance will be defined in turn.

Governance encompasses laws, regulations, and organizations, as well as governmental policies and actions, domestic activities and networks of influence, including international market forces, the private sector and civil society (Demetropoulou et al., 2010: 341). It entails the interactions among structures, processes, rules,

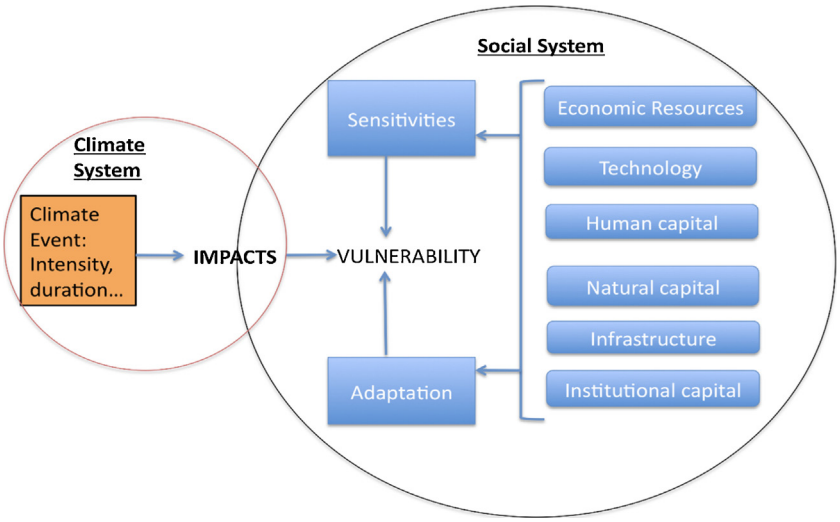

Fig. 2. The dimensions of vulnerability.

and traditions that determine how people in societies make decisions and share power, exercise responsibility and ensure accountability (Lebel et al., 2006; Raik and Decker, 2007; Cundill and Fabricius, 2010: 14). Thus, governance involves institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their legal obligations and mediate their differences (Armitage et al., 2009; Kiparsky et al., 2012).

Water governance refers to the range of political, social, economic and administrative systems that develop, manage, and distribute water resources (GWP, 2009: 14). It involves public and civil society organizations and comprises of norms, programs, regulations, and laws, relevant to the management of water resources (Hall, 2005; de Loe and Kreutzwiser, 2007). Water law establishes the formal institutional framework of rules within which people and organizations operate in relation to water and constitutes a foundation of water governance.

Adaptive governance is collaborative, flexible, and learning-based issue management across different scales (Folke et al., 2005; Gunderson and Holling, 2002; Olsson et al., 2006) with an aim at building flexible institutions and social networks in multi-level governance systems striving to improve adaptive capacity to deal with uncertainty, surprise and external drivers (Berkes and Folke, 1998). It includes continuous learning by interpreting and responding to ecosystem feedback and stakeholder participation in policy making to explore and understand uncertainty (Nelson et al., 2008; Hatfield-Dodds et al., 2007). The impact of the governance system on agricultural producers is a function of human, social, economic, technological, natural, and institutional capital. Each will be discussed.

1.3. Objectives of the paper

There is still considerable uncertainty surrounding the types of institutions or governance practices that achieve resilience or are conducive to adaptation (Eakin et al., 2011; Engle et al., 2011; Huntjens et al., 2012; Eakin and Lemos, 2006). This research explores how the water governance system of Mendoza, Argentina, sets conditions, facilitates, restricts, limits or creates opportunities for agricultural producers to help increase water availability, and improve socio-economic conditions by studying the water governance system's impact on the capitals (determinants of adaptive capacity) in Table 1. In other words, how is institutional capital maintained and created, and what institutions limit or inhibit the institutional capital of agricultural producers? Further, what changes to the institutional system might build the capitals that are determinative of adaptive capacity?

2. Methodology

The case study area was chosen because it is a dryland, regional water basin, with significant irrigated agricultural production exposed to significant climate change impacts now with more are anticipated into the future (see Section 1). An institutional analysis of the water governance system responding to climate change and drought was conducted. Relevant organizations, laws, regulations, policies and practices were identified and analyzed in relation to rural agricultural producers using a multi level analysis (see Gupta et al., 2013; Young et al., 2005). The findings are provided in Section 3. Thereafter twelve semi-structured interviews[1] were then conducted with key policy stakeholders (including government personnel, academics, and non-governmental organizations with deep knowledge of agricultural production, climate change, drought and flood).

Interviews explored the components of the institutional governance system, its workings, and the impact of the system on the assets (human, social, economic, technological, institutional, and natural) of the agricultural producers and their community. Interviewees were also questioned about how the water governance system might be improved. The objectives of the semi-structured qualitative interviews were to understand the effect of the governance system and practices on agricultural producers, and their capitals, and determine how effective the water governance system was in reducing the vulnerability of agricultural producers or impeding adaptation. These interviews were then coded and analyzed by impact on adaptive capitals (Table 1). This paper reflects the biases and beliefs of the interviewers, interviewees, and writers.

Stakeholders were selected through theoretical, non-probabilistic sampling based on stakeholder theoretical relevance to the research question and considering the key variables for the study area. The theoretical sampling does not seek statistical representativeness of the universe of actors, but to discover categories and their properties and to suggest the inter-relationships within the theoretical framework that was selected to be studies, to help refine or expand the concepts or theories already developed. Although this is a small sample size, the number of key policy stakeholders (people involved in irrigated agricultural, water and climate change) is not numerous, and by the end of the last

Table 1
Determinants of adaptive capacity. (Based on de Haan 2000; de Haan and Zoomer 2005).[a]

Capital	Description
Economic	The existence of monetary capital, financial means, wealth, productive resources, and others forms, which could contribute to the development of an adaptive capacity
Technology	The availability and access to technology – such as irrigation systems, flood control measures, warning systems, and others – as well the existence of a capacity to develop new technologies that could contribute to a more robust adaptive capacity
Human	The educational and knowledge levels, as well as expertise, we find in a system. Systems with the capacity to produce, disseminate and store information (high educational levels) have a better ability to understand and predict climate hazards, reducing their vulnerability to climate and climate-related events
Natural	The availability and access to basic environmental services (water, soil, seeds) that are fundamental to the viability of rural livelihoods
Social	The quality of relations among people, or the groups, networks, norms and trust people have available to them for productive purposes (Gootaert et al., 2004)
Institutional	Established institutions facilitate the management of climate-related risks – such as the existence and availability of insurance services, water conservation programs, and others – reinforcing the adaptive capacity of agricultural producers

[a] The IPCC (2001) lists these assets as economic wealth, technology, institutions, information and skills (human), infrastructure, and equity. Here infrastructure has been combined with technology given the focus on irrigated agricultural producers.

interview, saturation was achieved as no new information was being discovered. Although the findings are specific and have a limited and bounded application to the studied area, the analysis confirms the relevance of studying adaptation and resilience at the intersection of social, political, and economic dimensions and physical factors.

3. Overview of institutional water governance system in Mendoza

In Argentina, water is within the Province of Mendoza's jurisdiction. The predominant institution is the *Departamento General de Irrigación* (DGI), an organization created by, but independent of the provincial government. The Governor of Mendoza appoints (and the Senate ratifies) the superintendent, executive and the members of the Honourable Administrative Tribunal (5 members tasked with hearing water complaints), and Appeals Council (5 members tasked with hearing appeals of the Administrative Tribunal). A General Users Assembly acts as a surveillance committee and body of representatives of water users; it is governed by vote size that is proportional to property size. Fifteen Riverbed Inspectorate Associations (RIAs) exist in Mendoza (decentralized, financially autonomous, non-state, administrative, self-governed units funded by irrigators). Reporting to these RIAs are 166 Inspectors, who in turn employ *tomeros*, in charge of controlling irrigation infrastructure and enforcing water rights. A diagram depicting these organizations and their relationship to irrigators appears in Fig. 3.

Irrigated producers can be divided into three groupings. Small irrigators have lots less then 10 hectares and are generally fruticulturist and horticulturists; medium irrigators have lots from 10 to 30 or 40 ha and can be viticulturalists and/or horticulturists (approximately 20% access groundwater); big irrigators have properties from 700 to 1000 ha. These big irrigators access groundwater, produce wine, and have direct access to Managers of RIAs, the members of the Honourable Administrative Tribunal and the Appeals Council. The arrows on Fig. 2 depict the lines of influence that each size of irrigator has.

The most salient features of the institutional water governance system of Mendoza in respect of surface water is the inherence principle (the basis of water allocation). The use of public water is a right and is governed on the basis of water and ground inherence, or the principle that water is inherent to the ground where it is located (Provincial Constitution, 1916 (Articles 186–196)). One and a half century after the development of these legal rules and the Mendoza oasis (Montaña, 2007), this institutional practice hasn't changed; the condition that without irrigation, land is unproductive has not changed either. The inherence principle was originally to protect the land (its owners) against arbitrary interests and to guarantee that the land was not left without water and unproductive. Initially inherence was utilized in order to encourage the continuation of the geographical oasis and irrigated agriculture on the parcels of land with water. This leads to a double consequence. First the water interest can not be sold or transferred and second, the charges for the water and fees of the DGI and water users' associations continue, regardless of usage, and the right continues, regardless of failure to pay. The counterpart of this legal certainty for landowners with water rights was land lacking access to water, thus rendered of little value.

DGI oversees the complex web of full, superficial water rights (definitive, eventual, and private) and precarious rights (temporal, discharge). Definitive rights are those registered at the time of the promulgation of the Water Law (1916); eventual are those registered after the promulgation of the Water law (many in 1920); precarious can be revoked for justified resolution of the Superintendent; Drainage rights correspond to properties that use surplus water; private are those with water arising and ending within a property for which registration is voluntary (Diaz Araujo and Bertranou, 2003). Although a complex system of priority exists between definitive rights and eventual rights in order of their antiquity, followed by other rights, a conditionality on flow was established in the Constitution of 1916 such that until a measurement of the flow is made, all new concessions are eventual and require a report by the DGI and the vote of two-thirds of both legislative chambers (art. 194 Constitution of Mendoza). Because of this, no new definitive rights exist after the general water law of 1916 (Pinto, 2001). To make matters more complicated, DGI's registry of private water rights is completely out of date. Updating is constantly promised and never accomplished.

Water is priced based on property size (not volumetric usage). Access to groundwater is restricted because it not only depends on the ownership of a license for using it, but on the economic resources to operate the well since the construction, maintenance and operation costs are very high. Groundwater is also managed by DGI which commenced several years after the necessary laws (Laws 4035 and 4036 were passed in 1994) but not in conjunction with surface water; although naturally connected to the water system, ground and surface water are managed and regulated completely independently of one another. Water legislation in Mendoza focuses on supporting the agricultural economy through a priority system that recognizes first human supply, but then irrigation, industry, and fishing and plant ponds (in that order). Although surplus water can be reallocated, no interviewee recollected such an event occurring.

The institutional regime is centralized and hierarchical (in authority, power and capacity for action). However, there is also institutional fragmentation regarding water. In addition to the ground and surface water disconnect, water uses are separately managed by DGI, other organizations manage drinking water and sanitation, and river basin organizations exist in a separate sphere.

4. Findings

The impact of the water governance system on agricultural producers was analyzed based on the interviews and will be reported by effect on the resources or capitals necessary for the agricultural producers to adapt to climate change.

4.1. Human capital

In Mendoza, the irrigated area is considered part of the urban area; the rural is the non-irrigated area, occupied by dryland agricultural producers and *campesinos*. In the urban centre, life conditions are better (CNP 2010); indicators of human development, quality of life, and access to drinking water are higher in areas with irrigation than areas without (DEIE, 2006). In Mendoza, the irrigated oasis is regarded as the driver of development.

Within irrigated producers a generational shift is occurring, as young people are more likely to abandon the land looking for different opportunities in urban centres. This shift is in part promoted by low profitability of farming activities. Many small and medium producers sell the irrigated land and move closer to the

[1] These interviews were conducted within a broader investigation of governance conducted within the VACEA project funded by the Social Sciences and Humanities Research Council (SSHRC), the International Development Research Center (IDRC) and the National Science Research Center (NSERC). Seven interviews were conducted in Chile; six in Argentina; six in Alberta; and six in Saskatchewan.

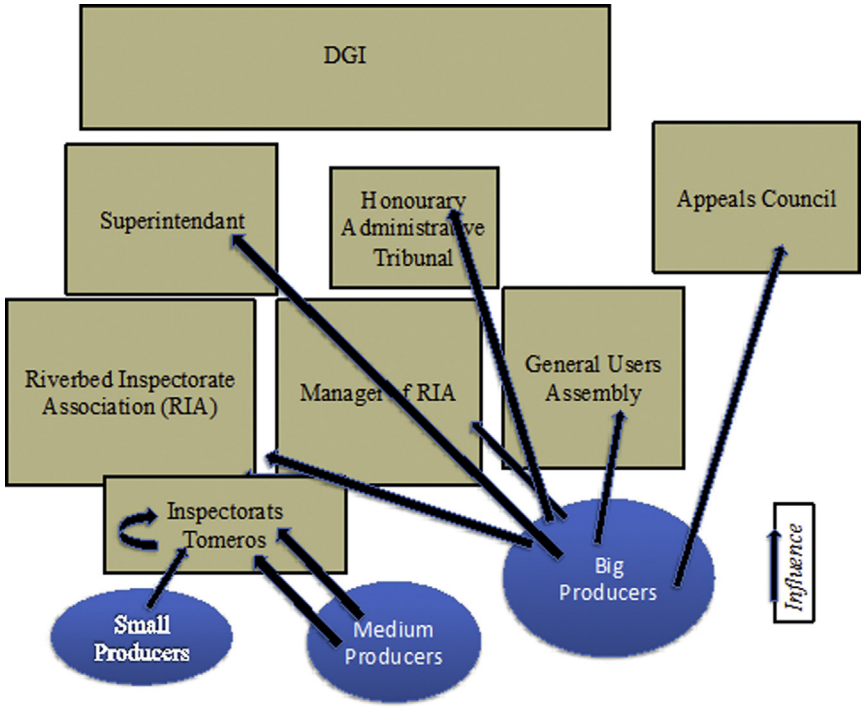

Fig. 3. Water governance organizational chart of Mendoza, Argentina.

urban centre, while the older generation regards the irrigated land as their identity. This practise may have implications for the future, as it is a part of an ageing of rural population.

Rural residents outside of the oasis are without water rights and unable to participate in the water governance structures described in Section 3. They are completely aware of their exclusion from the water governance system and on many occasions they organize to claim human rights to water. The information they manage about their condition of vulnerability, is not an output of high formal educational levels, but involvement in local networks. So here, human capital overlaps with social capital. However in these cases, being informed about their *rights* does not make any difference; they continue to be *legally excluded* from water rights.

Governmental institutions are great public information producers. Nonetheless, the information they produce is not as useful as it is supposed to be (especially for small farmers) because it is in a technical and sophisticated format. So, although there is lot of information available, is not easy accessible and it cannot strengthen adaptive capacities.

Within the irrigated producer community, there is also a highly disparate access to information. Small irrigators and horticulturalists have the weakest access to information. Medium agricultural producers obtain information through their irrigation associations. Large producers have access to information from vendors of goods, the Federal Institute for Agriculture and Livestock Technology (INTA), large institutions such as DGI, and research institutes, cooperatives they may belong to, and can hire consultants and specialists. Small producers have less access to information, less access to institutions like INTA and DGI, less interaction with vendors and research institutes, and less funds to hire consultants and specialists.

4.2. Social capital

Mendoza is characterized by groups with strong social capital or *associativism*.[2] However, social capital is geographically or spatially determined and there is a difference between formal and informal social capital, depending on the irrigator. Large irrigated producers are generally situate in the upper reaches of the valley at the headwaters where conditions for growing the grapes are optimal. They have formal bridging relationships with foreign investors and directly with DGI.

Small producers further downstream in the middle and low part of the basin suffer water shortages (Hurlbert et al., 2015) and formal social capital is less of a determinant of their adaptive capacity. For small producers, informal social bonds are more of a determinant of adaptive capacities than formal *associativism*. These producers rely on informal relationships within their own irrigation districts, or with their neighbours, fellow irrigators, *tomero* and inspector. There is a high degree of vertical and horizontal social capital amongst these producers, not existing to the same extent within the large agricultural producer category.

In times of water shortage, small and medium producers, without access to groundwater, rely on relations with the *tomero* and inspector to receive water. It is possible for a *tomero* to provide water to a producer who is in dire circumstances and at risk of losing vines or fruit trees. The informal institutional arrangement between producers and between a producer and the *tomero* is an

[2] Associativism refers to an institutionalized, lasting relationship network that provides actual or potential resources (Bourdieu, 1986).

important component of assistance and social capital. There is also a component of financial reimbursement for water within this relationship, which is separate and apart from the practices of the irrigation districts and formal water laws. *Campesinos* herding goats in the drylands never receive any water during peak runoff periods, but continue to lobby for their human right to water. These groups have strong internal social capital, but none of the informal and formal social capital of the other producers.

In Mendoza all irrigators are members of the Irrigators Assemblies. These ancient, formal, non- state, community organizations are the icon of the water governance system. However, irrigated producers do not feel represented by these assemblies and in many cases they do not even attend meetings. This is because only purely administrative issues are discussed (such as the setting of fees) and the organizations are not as democratic as they should be. Not all landowners have the same number of votes when choosing inspectors or voting on any decision. Votes are proportional to the size of the property varying from 0 to 8 votes (Bustos et al., 2008), and owners of less than 1000 ha do not have any vote right at all. So, in Mendoza even when there appears to be much involvement of irrigators in governance, there is no capacity for taking action on the basis of that involvement. This generates distrust.

Although the DGI conducts many workshops with irrigators, there are not any concrete outcomes or changes in practices of irrigation, or adoption of best agricultural practices as a result. Changes in agricultural practices come about as a result of informal cooperative practices whose formality only reaches "verbal agreements" between neighbours. Examples include agreements to exchange wells, build reservoirs of water, and adopt new technology or machinery. These best practices and initiatives are encouraged through bottom up measures, and not by top down measures imposed through a legal or regulatory framework.

Social capital acquires a different meaning for small and medium grape producers engendering opportunities for the commercialisation of their crops. This aspect of social capital will be discussed in the next section as it overlaps with economic capital.

4.3. Economic capital

Economic capital is a greater determinant than natural capital (e.g. lack of water) of agricultural producer adaptive capacity. The fact is that farmers stop producing not because of lack of water, but lack of profitability. Producers find production costs often are greater than gross crop sales. After a prolonged period in this state, producers sell the land for other uses or to larger producers. As climate change impacts increase, water shortages increase, and ecosystem services decrease (all resulting in compromised natural capital (see Section 4.5)), this dynamic may change.

High fixed costs as well as differential access to both markets and economic instruments increase sensitivity of small and sometimes medium agricultural producers. Each will be discussed in turn. The water governance system, and water charges and fees associated with inherence result in high fixed costs for producers. Producers pay these fees regardless of the quantity of water and as a result they are fixed costs that do not vary or adjust regardless whether the agricultural producer receives a crop or a partial crop from these lands. It is becoming a more and more common occurrence to run out of water. One producer stated, "I had to uprooted 2 ha of olives or grapes or plums, or whatever, because the water I receive is not enough as it was a time ago."

The inability to respond to scarcity or drought in Mendoza has a cyclical impact. Reduced production (reduced acreage of crops) or the complete loss of crops results in reduced sales and revenue, but the fixed costs of the water governance system does not allow the necessary capital for replanting of lost plants. For small and medium producers who can not afford the adaptation of accessing expensive groundwater, this squeeze can be debilitating and result in loss of the farm.

Small and medium producers are more vulnerable because of a flawed and limited access to large export markets that are dominated by large horticultural and viticultural producers. This is due partly to their size and partly due to market requirements. Small and medium irrigators must sell their produce to these large producers for the poor price established by large wineries and marketing actors, reducing their economic capital and ability to access technological and natural capital. The social integration network (see Section 4.2) allows them to enter into the local grape marketing networks, however, it is a circuit that restricts their ability to negotiate a better price. This places limits on profitability. Although this situation mostly impacts small producers, more and more frequently it is impacting medium producers as well.

Small horticultural producers of fruits and vegetables do not even have this containment net of being able to sell to big producers as they must integrate into a much more informal economy. Most small horticultural producers sell through intermediaries who charge fees to the producers as only a few sell their products at local city fairs. Small and medium producers struggling to make ends meet, often become seasonal, migrant workers, selling their labour to the large irrigators and viticulture operations. Once their fees and taxes are paid, these producers return back to their land.

Conversely, large producers are able to take advantage of numerous sources: foreign investment, national programs (such as Provincial Agricultural Services Program (PROSAP), or Overhaul and Growth fund), bank financing, etc. Medium producers may have access to PROSAP and the Overhaul and Growth fund (founded by the Interamerican Development Bank trough the Ministry of Agriculture). Small producers have targeted emergency relief and an Agricultural Social Program. However, many of the small and medium producers can not access these programs as a requirement exists that all fees and taxes be paid up, and many are in arrears. Another requirement that limits effective possibilities of accessing these loans is farm mortgage requirements. This procedure is so expensive that only large producers can afford it.

4.4. Technological capital

Technological capital is often perceived as the optimal adaptation strategy, without considering impacts on other capitals (e.g. natural capital or impacts on flora and fauna depending on run off), especially differential impacts on small and large producers with different levels of access. Technological capital is also regarded as the main adaptation strategy of irrigated agricultural producers, resulting in 'technological optimism' (Leach et al., 2012; Ulloa, 2013). Technological fixes are favoured such as reservoirs, dams or irrigation systems, etc. (Dietz et al., 2003) that appeal as 'engineering' fixes (Lampis, 2012) to reduce water shortages. Often these technological adaptation measures do not account for the possible transfer of vulnerabilities from one group to another or from one system to another (Mussetta et al., 2015).

For example, the building of the Potrerillos dam (Montaña and Boninsegna forthcoming) is the most important piece of infrastructure that regulates the seasonal supply of water at a basin level. This dam, built in the 90s, assisted irrigators by leveling the water flows of the river Mendoza allowing a more secure water source and more stability and predictability in water flows. But at the same time, this dam removed any water that was previously received by producers at the end of the basin, on the edge of irrigated area. Another example is waterproofing irrigation canals that increase the volume of water that each producer receives

because it prevents seepage loss, but it is also detrimental to the aquifer recharge.

In this regard, we believe that while the technological level of producers indicates their level of capitalization, there is no linear, unidirectional relationship resulting in better adaptive capacities. Access to technological capital is inequitably distributed amongst agricultural producers. 57% of producers have a low, precarious level of technology in their farms, and only 14% of producers have high-tech infrastructure (Mussetta et al., 2015). There is a considerable gap between the economic capacity of small, medium-sized and large producers, and it is intensifying. We believe the higher technological level does not equate into the best adaptation capabilities. The socio-historical context presents contradictions, as artisanal practices are forms of adaptation and large technological solutions (accessing groundwater) may be maladaptation. In addition, the technological approach does not consider alternatives for capacity building that is proper for the socio-historical contexts, nor does it make visible local adaptive options that do not necessarily include the implementation of agricultural technologies and complex infrastructures (David et al., 2013).

Large agricultural producers can access international as well as national funds in order to construct private water reservoirs and invest in irrigation technology (allowing a more efficient distribution of water). Technologies include adopting drip instead of flood irrigation, or lining and covering water channels. These are the most influential technologies for reducing sensitivity. Small and medium agricultural producers do not have the same ability to access international funds, credit, and this technology; many small producers who do not have paid up taxes and water charges are unable to access any funds.

In contrast, small and many medium sized irrigators often turn to artisanal practices in order to adapt to climate change because they can not access the economic capital necessary for other adaptation measures relating to technology and natural capital. These practices include: in-farm crop management practices for water saving that demand practical knowledge about irrigation and crops such as crop or furrow selection on each irrigation shift, or night watering. Technical dedication and a degree of initiative to adapt on the part of producers are required. Unfortunately, many producers cannot manage to develop these practices and acquire a passive attitude leading to the reduction of hectares of irrigation along with decreasing production.

4.5. Natural capital

The most significant degradation of natural capital relates to groundwater. Groundwater pumping is reducing natural capital as it is over exploiting and polluting the groundwater aquifer; producers have to drill deeper. Accessing groundwater is the only available practice for getting more (and sometimes enough) water. There is no other option. This adaptation option is completely mediated by economic capabilities. Only large irrigators and about 20% of medium irrigators can exercise this option (CNA, 2002). Under new climate, social, and economic conditions, this is an instrument just as exclusive as markets because this adaptation is only available to a select few that either have an already existing license or who can afford it. Small and many medium agricultural producers cannot afford the cost of searching for and building a well, the energy cost of using it, and the cost of maintaining it.

Obtaining a permit for groundwater use is regulated by Resolution 548/12, which provides a drilling permit upon paying a fee. Regardless of this barrier, some irrigators proceed to illegally pump. It is a highly used and expensive practice, either legally or not. Further, DGI has implemented a disguised groundwater market responding to pressure by large irrigated producers in areas with no or insufficient water rights. Producers wishing to access a new drilling permit must submit another unused or abandoned well, not necessarily on their lands. The more powerful can buy at very low prices the groundwater licenses of unprofitable producers. This practice further constrains the groundwater resource as no linkage is made between the aquifer, and the well that is being transferred in exchange for the new well. Buying groundwater is cheaper than buying neighbouring land with inherent water rights.

4.6. Institutional capital

The inherence principle, and its mechanism of deployment is rigidly uncompromising and for the most part does not advance institutional capital as it creates institutional barriers to adaptation and prevents integrated water management. This is illustrated in six ways:

4.6.1. Rigid supply management

DGI allocates water in accordance with proportional volumes of those with a right of inherence associated with their land. The quantity of water received is determined by the type of right (definitive or precarious) the land has. In times of excess, or in times of scarcity, DGI implements proportional adjustments to water allocation without considering variations in crop varieties or water demand, reducing in equal proportions of water volume each type of water license. As a result of this practice, a rigid system of water allocation becomes an equally rigid system of adjustment in the face of scarcity and variability; no adjustment or accommodation is made based on the needs of agricultural producers, their crops, or the timing of their growing cycle.

4.6.2. Rigid power structures

The inherence principle has built a strong but inflexible institutional capital or an irrigated oasis culture. The centuries old practice of water inherence has supported and retained the “water society” of Mendoza that consists of a power alliance between politicians and landowners in the oasis rendering lands outside worthless without rights. No actor or interest has emerged with enough power to change this inherence principle of water management, even with all of its shortcomings. Nor has any dominant sector had the political will to extend the oasis to drylands without water rights. This principle and the support for this water society takes precedence over all other interests, including mining.[3]

Today this principle of water inherence is supposed to provide irrigation guarantees to land holders in the oasis and in a manner the principle does. Even in arrears, landowners in the oasis continue to have a right to water. As such, the principle does protect the small and medium sized producers in arrears indefinitely. However, other aspects of irrigated business impact business—access to markets and to groundwater, finance, technology, and geographical proximity to the water source previously discussed.

4.6.3. Formal institutions (water law) not reflected in practice

Today, inherence does not guarantee water supply – as it was supposed to do – for several reasons: (biophysical reasons) the amount of water does not allow it; (administrative reasons) the DGI authority does not really have an accurate knowledge about the demand; (communicational reasons) communication systems

[3] In Mendoza, a Glacier preservation Law was successfully passed which in effect prevents the development of mining (at the expense of the irrigation interests) at the headwaters (Mendoza Glacier Preservation Law).

are deficient so that a producer has no chance to predict in advance how much water will be received; (informality and corruption). These characteristics of the Mendoza system compromise trust and accountability. There is always a doubt whether the powerful government actors are favouring some producers.

Along with the inherence principle not functioning as originally intended, the system of water rights also does not. There is no big real and practical difference between permanent and eventual water rights. Eventual water rights were only supposed to receive water after the permanent water rights had been fulfilled. However, because of the geographical and institutional practices of releasing water as it runs down the mountain and along the Mendoza river and canals, and because water balancing calculations do not occur in real time (only once a year) the eventual rights receive almost the same water as the permanent rights. Water is proportionally allocated to land based on land mass with rights.

4.6.4. Inability to adapt to changing land use

The inherence principle breeds another problem when lands begin to be used for purposes different than production. Given the lack of profitability of many small producers, the subdivision and/or sale of productive land for real estate business is one of the most interesting ways for farmers to improve their economic situation. This situation is encouraged because there is framented management of water and land: the first is situated at the provincial level and the second at the municipal level. The land use change moves forward at the pace of low profitability of farming, and advancing real estate interests. Here the principle of inherence raises serious consequences because lands keep their water rights, but use them for other purposes. In the better lands of the oasis (Luján, Maipú, Uco Valley) beautiful residences have been built within what used to be an irrigated oasis and is now a gated, expensive, garden community. Water rights that once produced viticulture and horticulture, now water flower gardens, golf courses and swimming pools for those who can afford them. These situations create a conflict arena when scarce water has to be distributed. While the law states that if the lands are not producing crops, the owners are obliged to relinquish the water rights, in practice this does not happen. The new owners (protected by real estate interests) prefer to keep and pay royalties to irrigate the extensive gardens (vegetation quite contrary to that originally envisioned of a desert oasis) because a land without water is a worthless land.

4.6.5. Redistribution of unused rights

Only in a few cases, do new owners give up their water rights. Where this does happen, this water is supposed to be redistributed, but it is unclear how this works. Producers demonstrate 'a strong territorial root/affiliation' and they argue that when someone gives up water rights, this water should not be taken far to another area. Instead it should be allocated to producers without rights but within their irrigation area. That is, they do not want water to be taken out from one area to another. "We must be alert," they say. However, the recording and accounting methods do not exist to determine what indeed is happening with any water not used by irrigated license holders.

4.6.6. Fragmentation, especially in relation to groundwater

The rigidity of the inherence hinders adapting to water shortages, because it creates formal, legal and practical barriers to obtain extra superficial water, the independent or fragmented management of groundwater functions as the mechanism that allows the system to remain rigid. Contrary to rigid surface water regulation, the weak regulation of groundwater shows relative accessibility when economic resources are available for producers and this generate a virtual water market on aquifers, determined not by the possibility of exchanging surface water rights but by the ability to afford the cost of the well and of the pumping (Montaña, 2008: 14).

So, the one who has the capital needed to maintain the well, has access to groundwater, which produces a concentration of water in just a few hands. Irrigators have a clear conception of surface water as a public good, while with groundwater is not viewed in the same manner. There is an idea of groundwater as private. However, by law, groundwater is as public as the surface (Cueto, 2015).

5. Possible solutions—alternatives to improve the water governance system

The inherence principle of water governance in Mendoza, Argentina limits institutional capital preventing adaptation for six reasons: it results in rigid supply management, in continues strong power structures that dominate agricultural production, formal water institutions (laws and rules) are not recognized in practice, there is an inability to change land use, unused rights are ineffectively dealt with, and water is fragmented especially in relation to ground water. People without water rights, living in the rural desert have no voice in the water governance system.

The principle of inherence does offer some protection for small and medium producers as water rights are attached to land, and this principle overrides such things as arrears of charges and fees. Strong social capital amongst small and medium producers allows some adaptation together with artisanal practices. However low market prices and lack of access to markets are the most important determinant of the lack of adaptive capacity of these producers. The younger generation lacks the same connection to preservation of familial land that has water inherence rights; many young people move to the urban oasis where human capital indicators are higher, taking jobs in other sectors.

Large agricultural producers with access to foreign capital have learned to use bridging social capital with DGI and foreign capital to locate upstream, buying land with water rights, accessing technological capital efficient irrigation equipment and expensive groundwater (illegally or by purchasing the groundwater rights of others). Natural capital is strained by these practices and the fact purchased groundwater rights have no link to actual ground water. Clearly groundwater policy is required (Llop, 2005), but how else could the water governance system be changed in a contextually appropriate way that is acceptable to Mendocinas? Interviewees explored several options. The next section will address the question, if water was the focus, how could the water governance system be changed to improve adaptive capacity?

Interviewees explored three options of water governance change would could occur in the future. First the water governance system could access current laws for changing water rights; second, Mendoza government could take action in relation to water rights in arrears; lastly, a system of transfers of water rights could be implemented. Each will be explored in turn. This research concludes that the most desirable option is a mix of public and private reallocation of the water, while maintaining the principle of inherence (see Sections 5.3.1 and 5.3.2).

5.1. Access current laws

Without changing the current legal system, a change to the water governance system could be made by reallocating water rights after a water balance is conducted. However, this can not occur during times of drought (which have characterized the last four years). In addition, at least three of the barriers to institutional capital must be remedied in order to make the current system work: the rigid supply management system must be fixed (see

Section 4.6.1); the formal laws not being reflected in actual practices must be remedied (see Section 4.6.3); and unused water rights must be dealt with effectively (see Section 4.6.5). In addition three further institutional barriers must be addressed:

(a) The annual water balance must be made transparent. The calculation of the volumes given to each water right holder is estimated by periodic measurements of water supply, and without reference to license priority dates, or lands and crop registries. These calculations are performed in a non-transparent way and never made public.[4]
(b) A comprehensive water balance must be conducted. The Constitution stipulates a water balance is to occur on a regular basis, but it has not been done for over 100 years. Consequently, rights entitlements havent formally changed since that time. It is possible to change the (superficial) water rights allocation in a time of surplus after a full water balance is conducted, but not in times of drought. If there is more water available, eventual rights will become definitive. But if there is a water shortage, the situation is the opposite. While this balance will determine the amount of water distributed to each concession 'it will not necessarily imply a greater amount of water in the respective endowment. It will but only set the volume of water corresponding to each type of right' (Pinto, 2001: 3).
(c) The conditions of the water distribution system must be fixed to allow for any changes in allocation. Interviewees did not believe changing rights pursuant to this process would make any difference given that at the time of delivery producers depend on the conditions of the *hijuela* (the smallest canal that ends up in the farm) and the smallness would prevent any greater delivery.

While definitive rights holders receive 20% more water than those with precarious, many farmers with no definitive licenses recognize that if they had it, they probably would receive more water and could increase the produced volume. But this would not improved their overall economic situation because the balance between the cost of production and profitability would not be "more positive". This point downplays the claims of many scholars who advocate equity through a reallocation of legal and formal water licenses (OIKOS, 2006).

5.2. Address unused water rights by passing new laws

Instead of changing water rights after a water balance (6.1), as is provided in the current legislation, legislation could be passed to change water rights in the following three ways. Each option has a different implication whether the land is abandoned lands or used for real estate.

5.2.1. Expropriate lands with inherent water rights not being used

The first option was explored for abandoned lands (other than those sold to real estate interests) in 2010. The intention of the government was to expropriate 13,000 ha in the south of the province. The controversial announcement was not intended as an adaptation to scarcity, but as a decision with a strong political foundation and a clear positioning on the development model of the region: expanding wine production and confirming the priority of agriculture use (over other uses such as mining and industry). Opposition came from landowners who complained that abandonment was the result of unprofitability due to low commodity prices. The only people who were in favour of expropriation were landless labourers who saw the opportunity to become the new owners of the expropriated lands. Ultimately, there was no political support and nothing was done.

The impacts of an expropriation would depend on what would happen to these lands after expropriation. If re-cultivated, these lands (those abandoned, not those sold for estate purposes) may not have enough water for a crop and generate a greater water demand overall. This would increase the amount of water-stressed crops and vulnerable producers. Another option would be to give these lands to producers who can render them productive (putting all the investment needed for groundwater irrigation), but this would increase the concentration in hands of the more powerful large farmers and expend the aquifers. As a result, the expansion of the production frontier is not recommended in times of scarcity. Similar experiences in other places have failed (Smit and Wandel, 2006). Maximizing the inherence principle during drought, is not recommended. It would generate negative adaptations or maladaptation. Reinstating these producers to farming would require economic adaptations and the Argentina and Mendoza government have little ability to assist in this regard. Moreover, the low viability of this option lies in the high political cost that it entails.

5.2.2. Extinguish water rights on unproductive lands

Another option is to extinguish water rights on unproductive lands and leave them uncultivated. By just 'removing' their water rights the water removed would appear to increase the general water volume for the other crops. In times of extreme drought this would mean less water stress on other crops. The problem with this option is that these lands are not using the water now, and this non-used water is already flowing along the canals. So, although this measure would increase formal water available (through new licenses) it won't increase real water availability. The overall irrigation system is already using that water and producers do not note it. Again, the matter is how to increase real water available, not how to improve formal water rights.

Moreover this change would be best for lands now residential (previously agricultural) that have retained water rights. In these lands with land use changes, it is not possible to do anything but force renunciation of rights and redistribute these volumes. But real estates interests have been and are strong enough to continue to avoid such measure.

5.2.3. Levy a non-use of water penalty

One option suggested by some officials, is that unproductive lands should pay a special water fee. This has been implemented in other countries as a means of encouraging use of allocated water rights (REF). In Mendoza, interviewees explained that the fee would be used to fund irrigation infrastructure on other lands requiring efficiency upgrades but lacking the economic capital to implement them. This technology would generate more efficient irrigation methods and a water surplus. So land owners of built lands with water rights, would pay a kind of 'right of surplus water hoarding' used to 'assit' small farmers to save water. This alternative never went beyond unofficial comments in government circles. It would be a fair option to preserve agricultural use. However, again, the real estate interests were able to stop any policy measure not favouring their interests.

5.3. Allow water transfer

Currently, water reallocation (which does not create new water rights) occurs by discretionary decisions or of *tomeros*, inspectors, or by DGI resolutions (Martin, 2008). There are no criteria for these decisions, so it is perceived by interviewees to occur as a result of the relative power of actors that prevents equitable distribution. It

[4] The scientific sector also makes its own estimates with the particularity that their methods are widely disseminated and their results are not exclusive determinants of policy decisions.

is clear that criteria are required to formalize this practise. There are three possible methods to formally allow transfer of water rights.

5.3.1. Public reallocation of surplus water

Several failed attempts have been made for the public reallocation of surplus water. In 1999, the Unique Waters Register (RUA) was introduced and implemented in 2003 to document and establish water surpluses and reallocate non-used water (limited by current infrastructure to those in close proximity) (Antoniolli et al., 2005). The application of RUA in 2003 to regulate the water market began to generate conflicts immediately, as it was a year of scarcity. Those with definitive rights could claim completion of their endowment with irrigation rights from lands where rights were not used. This gave rise to the conflict outlined in 6.2. With problems like these arising, redistribution by RUA was suspended on the eve of a dry cycle (Antoniolli et al., 2005).

The benefits could be the ability to reallocate unused rights to those with rights to reduce reliance on groundwater and the collection by DGI of fees (by transferring unused, non paying rights to those who would pay). This option would reproduce current inequality of access, as those currently not paying for rights would lose their rights and producers with secure water access would be given the opportunity to purchase.

If the water transfer were made by the public authority with the criterion of providing to the 'neediest,' this might be beneficial in another way. The state would determine who 'needs more water' and could ensure that those most in need have water. It would be an allocation on the basis of demand within a regulatory framework designed to manage supply. The criterion the authority decides to apply will determine who could be the potential beneficiaries. Hence, it is crucial that the policy goal authorities want to achieve is carefully considered. Will it be a more equitable distribution that enables small economically challenged producers? Or will it benefit those who have been producing?

5.3.2. Private reallocation of water (within the inherence)

Unlike the previous government controlled mechanism, in private reallocation the producers with excess water are supposed to decide where and how to deliver the water they do not use. Currently these transactions occur, without regulation or control. It was not clear from interviews that only excess water is 'reallocated.' Disadvantaged producers claim "someone keeps water that does not belong to them" (fieldwork). Informality is the current criterion for the distribution of these alleged surplus flows. Those who can pay, benefit with more water. The holders of the surplus benefit with what they get from these 'exchanges.' Therefore, the lack of regulation, also creates conditions for *tomeros* – through favours exchange – to apply a discretionary criteria for the allocation.

DGI does not, and would not, participate in decisions; the ones who buy water do not have full security the acquired water will be delivered. The only direct benefits are for those who sell water and potentially an intermediary (the person who delivers water) if they are paid for 'contacting' parties (Antoniolli et al., 2005). Some scholars maintain that this market surplus will be based on voluntary agreement and will allow social needs to be met in a flexible manner (Pinto 2004: 4). However, in Mendoza where government has few resources for social services, the added obligation of purchasing community drinking water in a market would in all likelihood be unfeasable.

To assess the impacts of this private allocation, we must address: who are those who have excess water and could benefit from this mechanism? Will it be those with less water demanding crops (olive and grapes); or those with the possibility of supplementing irrigation with underground water (speculating on the price of surface water in case the underground aquifer is over-exploited) ? Small fruit-farmers who do not meet either of these two attributes, would probably be the 'clients' of these volumes and they will remain the hardest hit (see Section 4.3). The water would remain in the hands of the most efficient farmers and those who can afford it, and will not significantly change their situation. A possible way to avoid this concentration would be that the state control these specific transfer with specific mechanisms to prevent the concentration in the hands of the most powerful and promote access to water to those in problems (even those who have no rights).

5.3.3. Private reallocation of water (without inherence)

The last option is the free exchange of water rights and the repeal of the centuries old water inherence principle. Those producers who have invested in infrastructure, shall be bound to pay any price for water if they do not want to lose that investment (irrigation, for example). Those who want to grow, but can not pay the water price, will be unable. Those rights owners that are not producing, could sell their water to others who are doing better and give different land a different use.

At the same time, the trade-off of the water market is well-known: flexibility and possible increase of efficiency. This would be harmful to equity and create opportunities of access for the most powerful. In Mendoza everybody is aware of the disadvantages of the market, and it is not highly regarded as an alternative. In Mendoza water authorities such as the DGI and the Mendoza government support the inherence principle as a main water governance instrument. To asses some possible consequences of water rights markets, we must consider experiences in other countries, such as Chile and the impacts on other water uses such as drinking water (where municipalities have to buy the water from private actors to provide water for communities) (Reyes et al., 2009). Refusal to implement a water market is based on the idea that water will be hoarded by those who can afford it. But some of this is already happening in Mendoza, even with a legal system that it is supposed to avoid it.

5.4. Integrating groundwater access

All options discussed have been in relation to surface water. However, groundwater is an important component of the equation. Although historically separate, and less regulated, groundwater management does appear repeatedly in DGI plans and projections and is the most implemented adaptive practice in times of scarcity. Groundwater contributes to stability for medium and large producers, but at the expense of farmers who do not have the assets to access it.

The rigid water governance system coupled with the lack of water, promotes underground water use that although not handled as a market, is just as exclusive and limited as a market. The exclusive modification of the surface rights system would not impact on groundwater management. However, a real improvement of the governance system must consider the subterranean water. Currently, there is no political motivation to change the status quo because today only smaller and less powerful farmers are those who are motivated to change the system. Large producers have no need to change because they can access groundwater. This is what needs to be discussed and changed. There is much literature surrounding the benefits of integrated management. However in practice, it remains a restricted and elusive.

Integrated management of surface and groundwater, should not be made to increase availability, but for a wise use. Any revision needs to be cognizant that policies and fees can distort the transfer of rights and produce a use contrary to hydrological purposes. For

example farmers may begin selling superficial water and using more ground water if it becomes cheaper.

6. Conclusion

Our analysis illustrates that the impact of water shortages is strongly determined by economic, institutional, human and social conditions. Institutional capital, and particularly institutional arrangements within the water governance system that prevent adaptation are important, but inter-relationships with other capitals such as social capital (bridging capital with government and foreign capital) and economic capital (ability to finance technology) are also important. Adaptation must be contextualized within broader socioeconomic processes that seriously condition adaptability. Capitals overlap: some producers adapt through social capital between themselves, others bridging capital with DGI and foreign credit. Adaptation always has an economic cost. A number of factors associated with producers' economic and financial resources prevent (or facilitate) the implementation of adaptive strategies.

The first step in choosing a reform to improve adaptive capacity and specifically Mendoza's water governance is to define what is meant by 'improvement.' Is it a system that facilitates equitable access to water, environment sustainability, and/or increased productivity? Further, any option chosen must be done with consideration of who will be the winners and losers, as well as potential social degradation or natural degradation. More research and exploration of these issues are required. In this manner it is clear reform of the water governance system is inherently political. Any previous attempts have had opposition or support from different groups in Mendoza with differing power levels.

It is clear that the current water governance system is not working (resulting in significant institutional barriers to adaptation including rigid supply management, reification of power structures, informal practices occurring in contravention of formal legal rules, inability to change land use practices, ineffective management of unused water rights, and fragmented groundwater management). There is not a fair playing field. Economic, technological, and natural capital is only assessed by large agricultural producers.

A robust governance system will not be achieved only by reaffirming or changing formal, legal, or institutional mechanism. Our study finds legal mechanisms changing the water governance system must not be attempted alone, given that the informal practices often do not reflect legal rules. In addition, infrastructure constraints limit effectiveness of a simple upgrade in surface water rights such that a greater volume of water may not be received. It depends on the state of the infrastructure and the proximity of the farm of the primary distribution channels. Lastly, more water is not a direct indicator of improved profitability, because it depends mainly on economic mechanisms, such as prices of yield. Suggestions made to address unused inherence rights do not appear to have much chance of success.

More flexibility is required to allow producers to adjust water delivered to water required. The current supply management system and fee structure prevents the management of water according to need or demand, an important adaptation.

Options of the government conducting a water balance have not worked. The government reallocating water will inevitably be mired in the same debilitating politics. To adequately manage demand the register needs to be updated and flexible allocation of water considering priority of crops is required. The problem here is who will be willing to decide who gets how much water, and for what? The important issue is that this system provides an efficient but especially equitable way to move water from one farm to another.

Flexibility is not only about getting more water. Producers need a more flexible system that gives them loans and better prices for their crops. Each driver requires a different flexibility mechanism, for example better access to markets and more flexibility quality standards. Flexibility is not just an ability of producers to adapt to new conditions, but consequences of the current system and the distribution of assets. The paper reinforces a call to develop an approach that highlights certain dimensions that single discipline approaches fail to problematize, especially considering non-climatic aspects of the problem. The analysis of capitals allow us to understand these issue.

Private reallocations of water, while maintaining the principle of inherence is the option most supported. The inherence mechanism is firmly maintained by the government with a view to ensure agricultural use of water and to avoid the transfer of rights between producers, namely the consolidation of water markets, thereby protecting small and medium producers. Even with all its difficulties, the inherence of water to land is perhaps the last chance that smallholders have to keep producing. What must be clear is that a system of water rights inherent to land, in a context of scarcity only ensures a minimum of water for everyone. There will always be a great portion of the water managed independently from the formal water governance system of inherence. This portion is today balancing the lack of water. Developing rules surrounding this practice would improve transparency, accountability, and ultimately fairness.

Strengthening the mechanism of water inherence and allowing limited transfers of water when technically able to do so within a canal system, for a limited period of time, might be a reasonable small step towards change. This reform would also require that issues of groundwater access, access of water for those without rights, and that significant institutional barriers be addressed. Most important is to increase the democracy of the water system. The decentralized system of irrigation and governance allows a modicum of democracy, however this needs revitalization to allow greater votes to small and medium producers, or equitable participation within the organizations, including within the DGI authorities.

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