Chapter 12

Integrated water management in Chile

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ABSTRACT: The present chapter presents a general overview of Chile's water resources, its water institutionality and water legislation, and the obstacles that have prevented a decided adoption of an integrated water management framework. We identify key actions that are required to effectively advance towards an integrated water management framework in Chile. The most important of these are the following. Groundwater users must implement groundwater user associations and integrate these to the Juntas de Vigilancia so as to apply conjunct surface and groundwater management. Additionally, the Water Code of 1981 establishes that water use right owners are responsible for water management. However, it is imperative to strengthen all WUAs (Water User Associations) so that each one develops a strong rule of law, effective conflict resolution, and effective collective management. Finally, water users should implement Supra Organizations of Juntas de Vigilancia to integrate different river sections and aquifer hydrogeological sectors allowing for an integrated management of different river sections and aquifer hydrological sections. This does however not require a water legislation modification.

Keywords: Integrated water management, water institutionality in Chile, limitations to implement IWRM in Chile, key actions to implement IWRM

1 INTRODUCTION

Chile was one of the first countries in the world adopting market rules for the allocation of their water resources, and allowing the participation of the private sector in the management of the resource. The Chilean Water Code of 1981 treats water as an economic good based on the following principles: (i) water in not a factor of production only for agriculture, but for other sectors too, and must be transferable like any other economic input; (ii) separates the property rights from (mobile) water and (immobile) land resources; and (iii) establishes water use rights as any other property right, allowing for leases and sales between willing buyers and sellers.

Some of the benefits achieved by this approach are that water markets have been an effective reallocation mechanism of water under scarcity in expanding urban areas and have opened the opportunity to satisfy the demands from important social and economic activities, have played a key role in mitigating the negative impacts from droughts, and have promoted private investments to increase efficiency in resource utilization. Compared to the situation in most countries in Latin America and the Caribbean, Chile's water policies are unusually conducive to efficient resource use and development (Southgate & Figueroa, 2006).

Water markets have often been criticized for its potentially regressive impact on low-income agricultural producers and for deteriorating water resource distribution between the poor to the higher income (Brajer *et al.,* 1989; McEntire, 1989; Cummings & Nercissiantz, 1992; Metzger 1988; Syme, Nancarrow, & McCreddin, 1999; Molle, 2004). Limited empirical observations from operative markets in Australia and South Asia show that water markets can be beneficial to small farmers. Research in Chile on the impact of water markets on small farmers, however, has been limited and no reliable conclusions have been reached to date. Hadjigeorgalis (2008) is a notable exception: Her results indicate that water use rights markets have not been inequitable with respect to offer prices; resource-constrained farmers receive the same offer prices for their water and water rights as wealthier farmers.

However, the intensification of the demand for water has accentuated the recognition that water resources should be best analyzed and dealt with in an integral manner. Integrated water resource management has been emphasized as a means to incorporate the interest of the multiple users and uses of water in the planning process. Peña (1999) has pointed out that the unsolved challenge of the Chilean water policy is to implement an integrated water resources management. Initial proposed policy reform efforts in 1992 included proposals to create river basin administrative organizations. However, this proposal encountered significant opposition. Additionally, as Bauer (2004) points out, river basin organizations were poorly defined in this proposal. The 1992 proposal was eventually withdrawn and a less-ambitious proposal was finally approved by Congress in 2005. This water policy reform did not consider the necessary modifications to incorporate integrated water resource management.

Additionally, Chile's water policy approved in 1999, established as one of its goals the implementation of integrated water management. More specifically it states as one of its objectives the need to adopt an integrated water management that internalizes decisions of multiple water users, taking into account short and long-term externalities associated with traditional water management frameworks. Integrated water management should also strengthen and coordinate the actions of the multiple public services involved in water management. The main proposed actions were the creation of river basin organizations and the development of a water master plan based on the diagnosis of actual water management problems at the basin level. To date, advances have been achieved in the development of water master plans in a small number of watersheds. These are the result of a strong impulse during the years 2000–2001; however, there have been no major advances since then and, thus, only a few river basins count with water master plans. At the same time, the proposal of creating river basin organizations has not received the necessary support, which explains the inexistence of these organizations in Chile.

The present chapter presents a general overview of Chile's water resources, its water institutionality, and the obstacles that have prevented a decided adoption of an integrated water management framework. Finally, key actions that are required to effectively advance towards an integrated water management framework in Chile are proposed.

The structure of the chapter is as follows. Section 2 presents a general overview of Chile's water resources. The water sector institutionality and Chile's water legislation is summarized in the third section; analyzing the limitations it imposes to achieve an integrated water resource management. Section 4 concludes the chapter presenting the main actions that are required in order to implement an integrated water management approach.

2 GEOGRAPHICAL SETTING AND WATER RESOURCES

A long narrow strip of land (no more than 430 km wide) between the Andes and the Pacific Ocean, Chile stretches 4630 km from near latitude 18°S to Cape Horn (latitude 56°S). Chile's total land area is 743,800 km^2, of which 21.2% is agricultural land (157,687 km^2) and 21.8% is forest (162,148 km^2). Arable agricultural land is 1,294,000 hectares, which is 1.7% of the total land surface. Urban area covers approximately 0.06% of the total surface. Currently it is estimated that the area of wetlands in Chile is 4,498,060.7 ha, equivalent to 5.9% of Chile's total land area.

Chile is divided administratively into 15 regions, and has nearly 17 million inhabitants, of which 89% are concentrated in cities, mainly in the Metropolitan Region (RM) and Valparaiso, with 31% and 9% of the population of Chile, respectively. Population growth has declined in recent years from about 2% in the early 90's to 1% in 2009 (World Bank, 2010); estimated crude birth rate of Chile is 14.33 births/1000 population (INE, 2002).

In the last 30 years (1980–2010) Chile's real GDP has grown at an annual growth of 6.2%. The economy is based mainly on exports concentrated on natural resource-dependent production processes that are highly dependent on water, such as mining and agriculture (Central Bank of Chile, 2010). According to World Bank, Chile has a per capita GDP measured in purchasing power parity of U.S.$ 15,331 in 2010.

In 2005, the five classes of water-consuming activity with the largest share of GDP were manufacturing (12%), retail, restaurants and hotels (10%), mining (8%), agriculture and forestry (4%) and electricity, gas and water (3%), while in 2005 the contribution to merchandise exports were mining (57%), industrial (31%), and agriculture, forestry and fishing (7%) (World Bank, 2011).

Chile's unique geography provides a variety of climatic conditions and a number of short river valleys running from the Andes to the Pacific Ocean. Two primary mountain ranges, the Andes and the Coastal Mountains span the length of central Chile and provide the limits to the coastal plain and the central valley. Precipitation ranges from near zero in the north to an annual 2000 mm in the south. The rainy season is in winter, June to September, and much of the precipitation is stored in the snowpack in the Andes mountain range. Water flows in most basins have a mixed origin, since its waters come from winter precipitations and spring and summer snow melt, presenting highest flows in summer (November–February) with pronounced reductions in autumn and winter (April–June). Additionally, inter-annual rainfall fluctuations show greater variability in the arid and semi-arid north (between Arica-Parinacota Region and the Coquimbo Region). South of 37°S, rainfall becomes more uniform. Thus, the hydrological regime of Chile is irregular.

Within the global context, Chile as a whole may be considered privileged in terms of water resources. The average total runoff is on average equivalent to 53,000 m^3/person/year (World Bank, 2011), a value considerably higher than the world average (6600 m^3/person/year). However, there exist significant regional differences: From Santiago to the north, arid conditions prevail with average water availability below 800 m^3/person/year, while south of Santiago the water availability is significantly higher reaching over 10,000 m^3/person/year (see Figure 1).

Annual water withdrawals in Chile average approximately 4000 m^3/second (World Bank, 2011). Of this total amount, almost 85% is used in non-consumptive hydroelectric generation. Consumptive water use in Chile is dominated by irrigation, accounting for 73% of the consumptive water use. Up to 12% of the total consumptive water withdrawals are destined for industrial use, and mining and potable water supply account for 9% and 6%, respectively.

In the northern Chile desert, approximately between 17° and 26° south latitude, the limited water resources sustain a few coastal cities, some specialized agriculture, and large mining operations such as the main copper mining area in Chile. In north central Chile, between 26° and 33° south latitude, there is an adequate supply of water in a few river valleys for canal irrigation. Water storage reservoirs have been constructed to support these irrigation systems, especially in the Limarí Valley where three reservoirs have a joint storage capacity of 990 Mm^3. Central Chile, between 33° and 39° south latitude, contains the nation's major urban and industrial areas, including: Santiago with a population of 5,700,000. Irrigated crops include fruits, vineyards, basic grains, forage, and vegetables. Industrial products include processed food, pulp and paper, chemicals, plastics, and petroleum products. Also central Chile remains the region with the greatest hydroelectric generation capacity, especially in the Maule and Bío-Bío basins. Southern Chile, south of 39° south latitude, is humid, forested and scarcely populated. There is little irrigation in the area, which produces

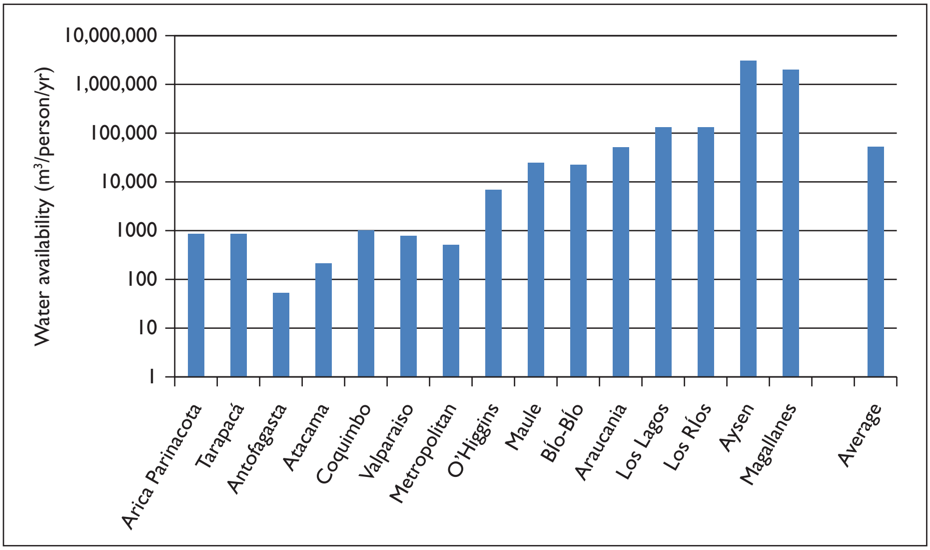

Figure 1 Average water availability per person per year (m^3/person/year) (World Bank, 2011).

forest products, cereals, dairy and livestock, potatoes, and sugar beets. Because of its cool water, clear lakes, and coastal fjords, this area contains Chile's large aquaculture industry. In 2008 there were an estimated 493 marine and 185 freshwater-intensive salmon and trout farms in the region (ECLAC, 2011).

Chile has a high level of coverage of potable water and sewerage treatment systems. In 2010, 99.8% of the urban population (SISS, 2004 & 2011) and at least 72% of the rural population had access to improved potable water (Donoso & Melo, 2006). The national coverage of sewage treatment has significantly increased from 10% in 1990 to over 80% in 2010 (World Bank, 2011).

The situation of water resources over the past three decades in Chile has probably been more influenced by the country's development strategy than by the water sector itself (World Bank, 2011). The empowering role of the market and the promotion of an export-oriented economy based on products such as copper, fresh fruit, wood and pulp, salmon, and wine – all of which use water in their production process – have led to a significant increase in water use, particularly in relatively water-scarce water basins of the northern and central parts of the country. At the same time, water is increasingly becoming a limiting restriction to further economic development. As shown in Figure 2, most of the regions north of the Metropolitan Region have to deal with hydrological droughts, since water demand exceeds its supply.

Climate change impact projections indicate that water as a limiting factor will increase due to reduced water availability. Chile has developed important efforts to estimate the potential impacts of climate change (MMA, 2011; ECLAC, 2009 & 2012). These models project a general decrease in rainfall, mainly in the central and southern regions (30–42°S). This reduction becomes more important from the central valley towards the Andes mountain range area, showing reductions around 40% by the end of the century. Analyzing potential impacts on temperature, the models indicate that there will be an increase in all regions of the country between 2 and 4°C

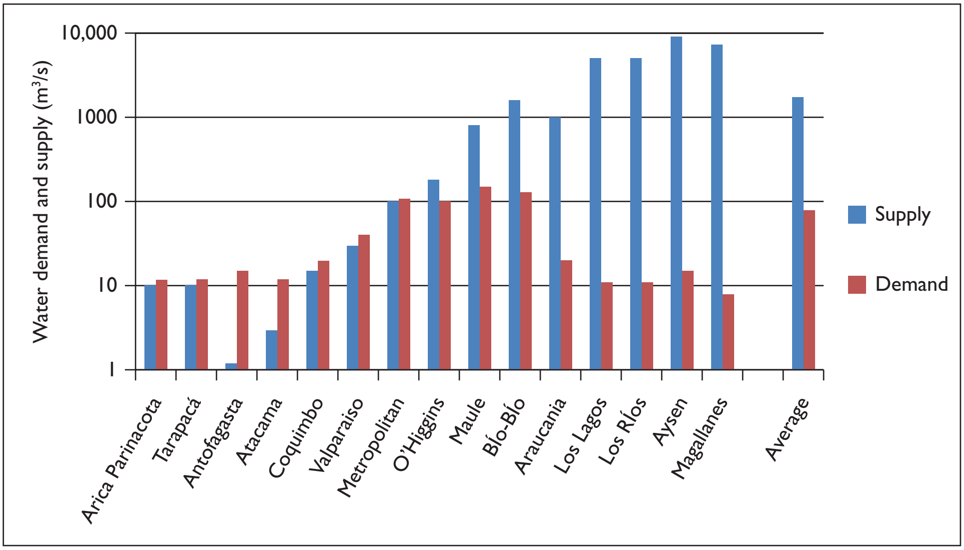

Figure 2 Water demand and supply per region (m^3/s) (World Bank, 2011).

by the end of the century. This temperature rise increases from the coast towards the Andes mountain range and decreases from the north of the country towards the south (ECLAC, 2012).

The availability of water resources is closely linked to climate variations, especially of precipitation and temperature. Thus, two effects are anticipated on what concerns water flows. In first place, there will be a reduction of total water flows at the basin level. This effect is due to the decrease in rainfall and a reduced snow accumulation in the Andes mountains; models project reductions that can reach up to 70% with respect to mean annual flows. In second place, there will be significant changes in the seasonality of water flows, due to an advancement of up to one month on the date of the centroid of water flow regarding the historical period (MMA, 2011).

In practice, the reduction in surface water availability will be dealt with by a proportional (re-) distribution of water according to each user's water use rights. However, in the medium and long term this approach may be insufficient to prevent significant reductions to private investment and increased conflicts between users. In the case of groundwater, on the other hand, the lack of user organizations in almost all of the aquifers of Chile prevents the establishment of specific actions to allocate water in a sustainable and peaceful manner. As a result of this trend, greater competition for water resources is foreseeable, as well as greater conflicts.

In addition to the projected changes in the supply of water resources, it is important to consider other processes such as economic and social, which are expected to change demand patterns, and therefore should be considered in the analysis of future water management challenges. The historical trend shows that all consumptive water uses have increased since 1990; total consumptive water use has increased 13% between 1990 and 2006. Industry is the sector with the highest consumptive water use increase (79%), followed by potable water and mining (48% and 46%, respectively). Furthermore, it is likely that many of these trends will continue in the short to medium term. Figure 3 shows the 2050 projected water demands by economic sector, indicating significant increases and thus greater hydrological droughts throughout the country.

Thus, it may be expected that the high level of conflicts between individual water users and between them and the Dirección General de Aguas (DGA) will increase in

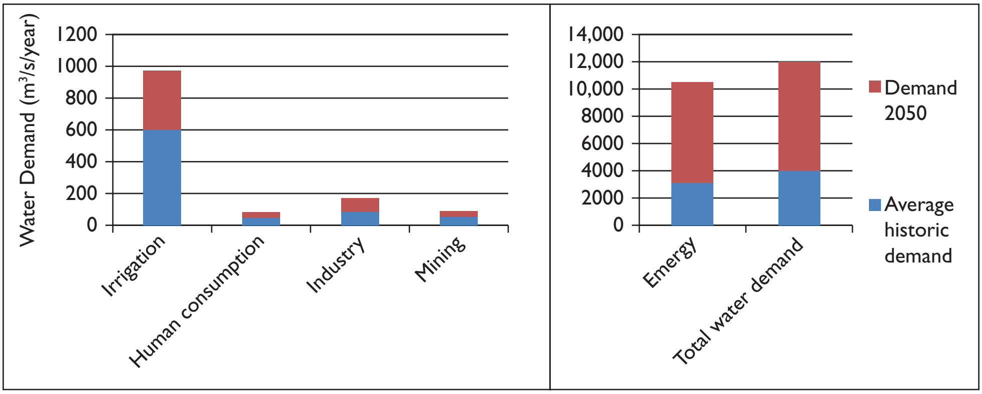

Figure 3 Average historic water demand and projected 2050 water demand (m^3/s/year) (Vicuña *et al.*, 2012).

the future due to the growing pressure on water resources. In order to minimize the negative impacts due to the increased water stress, it is essential to implement Integrated Water Management systems (IWRM). The feasibility of implementing IWRM in Chile, depends on the limitations imposed by its water legislation and institutionality to achieve an integrated water resource management. In the next section the water sector institutionality is being summarized.

3 INSTITUTIONALITY

Under the Water Code of 1981, the State reduced its intervention in water resources management to a minimum and increased the management powers of water use rights holders that are organized in Water User Associations (WUAs). The water resource management roles assigned to the State include:

– Measure and determine the availability of water resources and to generate the necessary data and information that allow for a well-informed management of water resources on the part of WUAs;
– Regulate the use of water resources avoiding third party effects and their overexploitation. For that purpose the State must analyze water resource availability and potential water use conflicts before granting new water use rights, authorizing water use right transfers and other authorizations such as changes in water distribution infrastructure;
– Conserve and protect water resources, by means of an environmental impact assessment of investment projects, establishment of minimum ecological flows and environmental policies.

However, multiple central authorities (ministries, departments, public agencies) are involved in water policy making and regulation at the central government level. In Chile the number of actors involved in water policy making is 15; one of the highest of OECD countries that were surveyed in an OECD (2011, 2012) study on water governance.

According to Vergara (2010), there is a distinction between centralized and decentralized institutions. Centralized organizations comprise the administrative bodies of the State. These centralized institutions include water quantity and quality management bodies and the judicial system that resolve most water use conflicts. Decentralized bodies are represented by user organizations, which are private organizations that are not part of the State administration.

The Dirección General de Aguas (DGA), part of the Ministerio de Obras Públicas (MOP), is the main public institution and is responsible for monitoring and enforcing water use rights. With its 15 regional offices, it collects and maintains hydrological data and Public Registry of Water use rights (Registro Público de Agua, RPA). As the leading government agency in water resources management it develops and enforces national water policy. In this role it has: Led efforts to amend the 1981 Water Code and developed a National Water Policy. In general, the DGA has maintained a limited role in accordance with the paradigm of limited state interference on which the Water Code of 1981 is inspired.

The Dirección de Obras Hidraulicas (DOH) is a unit of the MOP that plans, designs, coordinates and supervises the construction of major hydraulic public works, such as water dams. Its programs include not only infrastructure investment for water management, but also primary storm water infrastructure, flood control, and infrastructure for rural health services. A third important institution is the Comisión Nacional de Riego (CNR) of the Ministerio de Agricultura that establishes the policies and programs for the irrigation subsector. The CNR is headed by a Council of Ministers and an Executive Director. The Council of Ministers that includes the Ministers of Agriculture, Economy, Development and Reconstruction, Finance, Public Works, and Planning coordinates the institutions involved in irrigation and drainage, and an Executive Secretariat, which conducts research and implements programs and projects in order to submit proposals to the Council of Ministers. The Executive Director conducts studies and implements irrigation plans and projects. The CNR also administers a subsidy whose objective is to incentivize the adoption of water conservation technology by farmers (Ley 18,450).

Several institutions form part of the judicial system. Since neither the DGA nor any other governmental agency has authority to intervene in water conflicts, water use rights owners resolve their disputes either through voluntary negotiations, involving their respective WUAs, or through ordinary civil courts. Due to the lack of an effective conflict resolution mechanism, numerous conflicts end up in the hands of the courts (Bauer, 2004). Judges usually ask the DGA for expert opinions in any particular case, although they are not required to consult with experts. Broader conflicts over water, between different economic water consuming sectors and between water users and the DGA, are resolved in the Regional Court of Appeals. The decisions of the Court of Appeals may be appealed to the national Supreme Court. In addition, the Controlador General de la Republica controls the legality of various judicial and executive acts. This control includes the establishment restrictions and prohibitions on new water use rights concessions and on the declaration of scarcity, which allows for the intervention of the DGA in water management.

The Water Code of 1981 establishes that water use right owners are responsible for water management. Water user management has existed in Chile since the colonial era, and currently there are more than 4000 Water User Associations (WUAs) (Dourojeanni & Jouravlev, 1999). Three types of WUAs exist in Chile and are recognized by the Water Code of 1981: Water communities, channel user associations, and vigilance committees. Water communities are any formal group of users that share a common source of water. Channel user associations are formal associations with legal status that can enter into contracts; these associations operate on a distribution channel system. Vigilance committees are comprised of all the users and channel associations on any river, river section, or stream; they are responsible for administering water and allocating water to different channels. Some vigilance committees and channel user associations manage reservoirs for irrigation water and finance their operations with small hydroelectric plants.

The different user organizations have some common competences. In first place, their primary responsibility is the distribution of water resources between water users. Secondly, the management decisions are voted in general meetings by shareholders in proportion to their water use rights shares. Thirdly, under drought conditions, water is distributed proportional to the amount of water use rights each water user holds.

In 2010 the number of water communities was more than 10 times the number of channel associations; this is due to the fact that it is easier to form a water community than a channel association. Water communities and channel associations are responsible for both the management, maintenance and renovation of more than 40,000 km of primary and secondary channels, as well as dams built by the private sector or transferred to the user associations by the State (Verges, 2010). At present there is only one groundwater community in the country, in the region of Atacama. The Water Code of 1981 establishes that any aquifer that has been declared under restriction or protection must have a groundwater community. The compliance of this regulation is very low since several aquifers have been declared under restriction and protection and have not formed groundwater communities.

The vigilance committees are different from the other two types of WUAs, since all their competences and legal powers are over surface water before it's withdrawn. Since the Water Code reform in 2005, vigilance committees also must integrate groundwater into its jurisdiction, in an attempt to move towards a conjunct surface and groundwater management. Its main responsibilities are:

- Generate hydrological information in order to improve user's understanding of the water system;
- Manage surface- and groundwater withdrawals;
- Surveillance and monitoring of surface- and groundwater withdrawals;
- Water extraction enforcement;
- Application of sanctions to non-compliers.

Many of these WUAs have professional management (Hearne & Donoso, 2005). The effectiveness of some of these institutions in managing irrigation systems and reducing transactions costs for water market transactions has been noted (Hearne & Easter, 1995 & 1997). However, according to the DGA and the Dirección de Obras Hidraulicas (DOH), a large percentage of these institutions have not updated their capacity to meet new challenges. Many managers of these user organizations do not have a sufficient technical capacity and do not effectively communicate with their members. Additionally, Bauer (2004) points out that vigilance committees have not been effective in resolving inter-sectoral conflicts. To address some of these concerns, the CNR, DOH and DGA have implemented programs to train WUA managers and directors (Peña, 1999; Puig, 1998).

Brown (2004) has pointed out that the current water institutional structure has allowed for a multi-sectoral approach to environmental issues concerning water quality under the framework of Chile's environmental law (Ley Bases del Medio Ambiente). In Chile, most of the institutions related to water quality are separated from those that manage water quantity. In 2010 major changes were made to the Ley General de Bases del Medio Ambiente of 1994 (Law n° 19,300) taking into account recommendations of the OECD (OECD, 2005), as well as international experience. This institutional reform intended to (i) rationalize the competence of multiple agencies in the area of water quality management and to (ii) integrate and improve the effectiveness of Chile's environmental regulation (Library of Congress of Chile, 2010). The new Law (n° 20,417) created three new entities that replace the previous Comisión Nacional del Medio Ambiente (CONAMA): (i) the Ministerio del Medio Ambiente (MMA) with responsibilities in the formulation and implementation of water quality policies, plans, and programs also ensuring the protection and conservation of renewable natural resources such as water; (ii) the Servicio de Evaluación Ambiental (SEA) which is responsible, through its regional offices of environmental impact assessments, of managing, promoting, and facilitating public participation in the environmental evaluation of investment projects, and of presenting to the Council of Ministers a proposal of the environmental qualification resolution (Resolución de Calificación Ambiental, RCA); and (iii) the Superintendencia de Medio Ambiente (SMA) responsible for the monitoring of the compliance of the RCA, decontamination plans, and quality and emission standards. The Environmental Courts (Tribunales Ambientales) dependent of the Ministerio de Justicia were created in 2012 in Antofagasta, Santiago and Valdivia. The core competencies of these are related to environmental damage claims (Contreras, 2010).

However, Chile's water institutionality presents important limitations to effectively address integrated water resource management. In first place, Chile has sought to create institutional arrangements in which each economic sector has a defined regulatory framework, with appropriate incentives for the efficient management of resources in their particular area. This approach has not allowed for an effective management of the multiple interactions that arise between the public and private sectors present at a watershed level. Secondly, the fragmented water institutionality leads to the lack of a strong institution that identifies, formulates and implements national water policy as well as gives coherence to the actions of the various other institutions. In third place, OECD (2011, 2012) concludes that Chile's water institutionality presents obstacles to achieve an effective horizontal coordination between public agencies at the central level as well as a vertical coordination. The most important of these obstacles are the excessive fragmentation of Chile's water institutionality, the existence of overlapping and unclear allocations of responsibilities, competition of powers between ministries, lack of an adequate budget for public agencies, and the lack of citizens' concern for water policy.

Furthermore, the Instituto de Ingenieros (2011) points out that the current practice of managing water resources at the level of a river or aquifer section as if they were independent of other sections of the river basin presents limitations for the implementation of an integrated management. The Water Code of 1981 considers river sections and aquifer sections as independent bodies of water. Thus, each independent section has a WUA that optimizes water resources for its water users without considering downstream effects or impacts on groundwater users. For example, in the past three years that have been characterized by drought, several channel user associations have lined their channels so as to reduce water percolation and deliver more water to their surface water users. This is an optimal decision for surface water users, however, it significantly reduces groundwater recharge. What is more worrying is the fact that most of these investments have been subsidized by the CNR. Thus, government funded investments generate externalities on groundwater users.

Figure 4 depicts in a simplified diagram the negative impacts of this water legislation on downstream users when a river is separated in two sections. In the first section assume that there are two main water users: Agriculture and a potable water supply company. Agriculture extracts 80% of the available water flow while the potable water supply company extracts 20%. Suppose that agriculture's water use efficiency

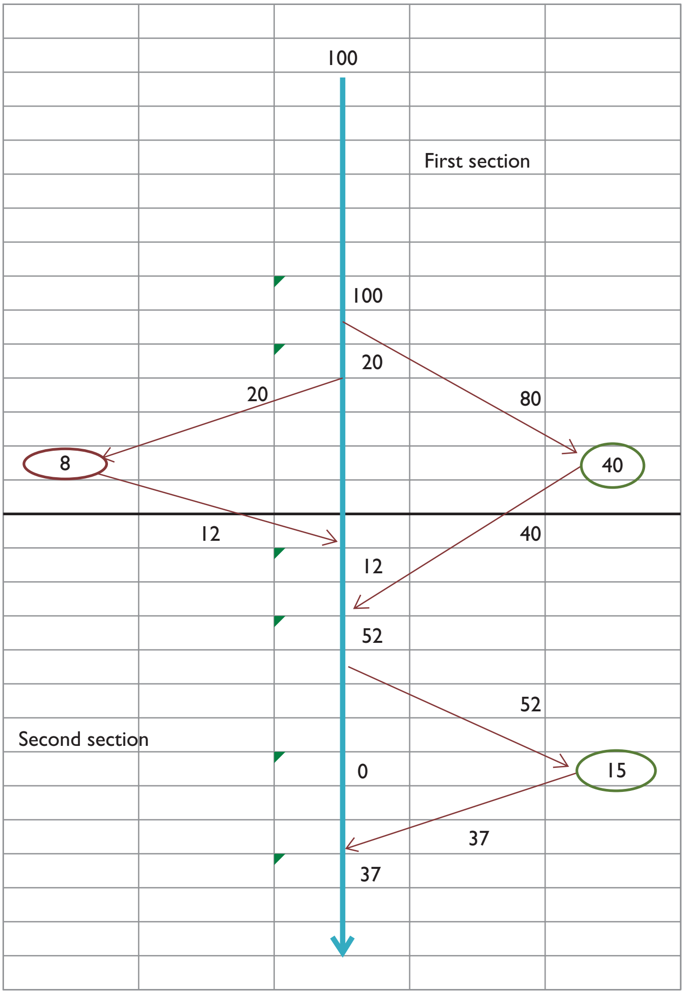

Figure 4 Simplified diagram of a river basin divided into two sections (own elaboration).

is on average 50% and that the potable water supply company has a water loss of 15% due to leaks and an inefficient distribution system and returns 25% in the form of treated water. The second section of the river receives water from the return flows from agriculture and the potable water supply company. Assume that this second section has only one user type that is agriculture, with an average water use efficiency of 29%. In this section agriculture consumes the total water available (52% of the original water flow) and returns 37%. Suppose that this final water flow availability satisfies ecological water flows at the final portion of the river basin which require 25% of the original water flow.

Now suppose that given a severe drought which has reduced water flows from 100 to 80 in the river basin, agricultural producers in both sections decide to increase their water use efficiency by 46%, taking advantage of the government's subsidy to adopt water conservation technology. This implies that the agricultural users in the first section reach a 73% water use efficiency, while agriculture in the second section achieves a 42.3% water use efficiency. At the same time, given population growth, the potable water supply company must increase its water extraction by 50% thus reducing the participation of agriculture in the first section to an extraction of 56%. However, given the increase in water use efficiency, the effective water consumption of the agricultural sector increases from 40 to 41 (Figure 5). The total return flow to the second section of the river basin is 43.4% lower than in the previous case (Figure 4). Note that the first section presents a 20% reduction while the second section sees their water flow reduced by more than twice that amount, due to the increased water

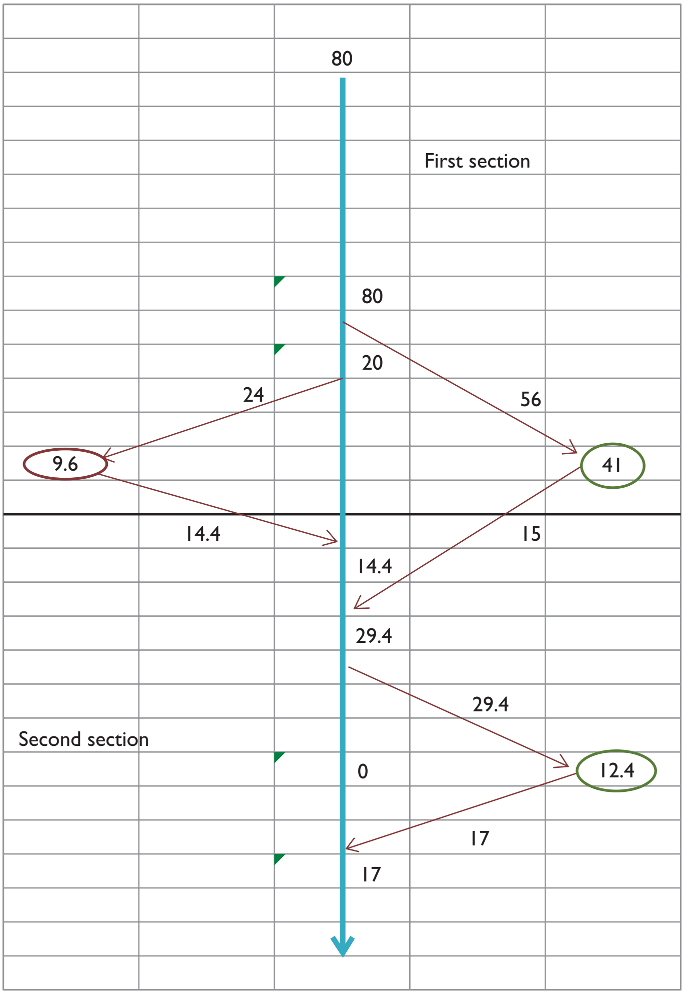

Figure 5 Simplified diagram of a river basin divided into two sections under drought and increased water demand and water use efficiency. (own elaboration).

Table 1 Water balance of each sector of the Copiapó Aquifer (DICTUC, 2010).

Sector	*Water Inflow (l/s)*	*Recharge (l/s)*	*Water use rights (N° Wells)*	*Water extraction (l/s)*	*Water outflows (l/s)*	*Hydrologic balance (l/s)*
1	19	1901	39	2187	513	–18
2	513	173	51	3380	66	–172
3	66	967	71	4107	118	–151
4	118	681	77	4115	227	–526
5	227	220	127	3895	112	–583
6	112	144	75	1938	0	–283

use efficiency in the first section. Thus agricultural users reduce their water extraction due to the drought and reduced return flow. The effective water consumption of farmers in the second section is 17% less than the previous case. The reduction is lower than the decrease in water availability due to their investment in water conservation technologies. Despite the increase in water use efficiency, agriculture in section two is clearly a loser. Finally, in this case, the second loser is the environment since final water flows are 17, well below the required amount of 25. This occurs at present in Chile's river basins from the Metropolitan Region to the north since minimum ecological flows were not set prior to the total allocation of available water flows.

Table 1 shows the hydrological connection between the six sections of the Copiapó aquifer, a division defined by Alamos and Peralta (1987) for practical reasons and following the natural narrowing of the Copiapó Valley. However, at present the DGA interprets these sections as Hydrogeological Sections which implies that each section must have a groundwater user association which takes water management decisions independently from others. Given the water flows between sections, four independent water management plans are clearly suboptimal to an integrated water management plan.

4 KEY ACTIONS REQUIRED TO ADVANCE TOWARDS AN INTEGRATED WATER MANAGEMENT IN CHILE

The interface of water resources and economic development is complex and includes many specific linkages. This wide array of important linkages that present many synergies, explains why pursuing each goal separately reduces the complex process of human and economic development to a series of conflicting, and unsustainable interventions. In addition, the interface of water resources and the achievement of sectoral development goals occurs at several different institutional levels, explaining why water resource policies in Chile have evolved in a fragmented and piecemeal fashion. Under this framework, policy objectives have been set without consideration of the implications for other water users and without consultation across sectoral and institutional boundaries. This traditional approach to water management has, in general, proven to be an ineffective policy strategy due to the fact that these problems fall outside of the normal purview of the agencies tasked with addressing them and, thus, require cooperation from multiple sectors. In order to optimize water resources for development, Chile must overcome constraints and thus generate an effective institutional coordination and make appropriate investments and management arrangements within broad planning and policy initiatives. In general, the solution can be found by greater institutional concentration since sectoral development goals occur at several different institutional levels.

In order to advance towards the implementation of IWRM Plans in Chile, it is necessary to implement the following key actions:

1 Increase the awareness of both the political leadership, water users and the society at large about the urgent need to move towards IWRM so as to involve stakeholders;
2 Implement groundwater user associations;
3 Integrate groundwater user associations to the Juntas de Vigilancia so as to implement conjunct surface and groundwater management;
4 Strengthen all WUAs so that each one develops a strong rule of law, effective conflict resolution, and effective collective management;
5 Implement Supra Organizations of Juntas de Vigilancia to integrate different river sections and aquifer hydrogeological sectors. This does not require a water legislation modification;
6 Implement efficient negotiation and conflict management since it will not be able to please everyone;
7 Work with the media to constantly inform society on the advances and short term wins so that society at large maintains its motivation towards the change process.

It is important to highlight, however, that there are no universal models that can be implemented. The specific solution and necessary action plan is country-specific. In addition, the experience indicates that IWRM Plans can be developed from scratch or be built on existing water plans. However, independent of the initial approach, it is clear that the strategies must go beyond the actions needed to solve current problems or to achieve immediate objectives; the implemented strategies should aim at promoting more strategic and coordinated decision-making on a dynamic basis so as to advance towards the development and implementation of IWRM Plans.

5 CONCLUSIONS

Lenton, Wright & Lewis (2005) remark that Integrated Water Resource Management (IWRM) builds on three basic pillars: (i) an enabling environment of proper water resources policies and legislation; (ii) an institutional framework of capable institutions at national, local, and river basin levels; and (iii) a set of management instruments for these institutions. Thus, IWRM allows for a more coordinated decision-making process across sectors and scales.

Hence, as Global Water Partnership (2000, 2004a) indicates, implementing an IWRM Plan is significantly different from the traditional approach used to develop water plans. Firstly, an IWRM Plan lays down a framework for a continuing and adaptive process of strategic and coordinated action and, thus, is dynamic rather than static. Secondly, implementing an IWRM Plan requires the involvement from multiple sectors. Traditional water plans tend to be concerned exclusively with water supply and demand issues, however, an IWRM Plan looks at water in relation to other ingredients needed to achieve economic development. Lastly, since an IWRM Plan allows for a coordinated decision-making process across sectors and scales, it requires more extensive stakeholder participation than traditional approaches.

Chile's current institutional framework makes it difficult to develop a multi-sectoral water management approach since it leads to single economic sector water planning. At the same time, Chile's water legislation favors the management of water resources exclusively for independent hydrological sectors, presenting legal obstacles to implement integrated water management. The problems that have been identified are not unique to water management in Chile. In general, they are present in many parts of the world and require a non-structural solution and a new approach to planning and management. In this context, Chile must overcome constraints through appropriate institutional reforms and legal modifications that allow different WUAs to integrate and develop an Integrated Water Resources Management (IWRM).

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