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Summary report on the current water rights framework in Chile

A report submitted to AusAID as part of the study:

Copiapó River Basin, Chile – analysis study of shortfalls in water rights, industrial usage and social requirements

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1. McFarlane, D. and Norgate, T. (2012). Summary report on Copiapó water yields and demands. Unpublished report to AusAID as part of the study: "Copiapó River Basin, Chile – analysis study of shortfalls in water rights, industrial usage and social requirements" from the Minerals Down Under Flagship, CSIRO.
2. Moffat, K. and Lacey, J. (2012). Summary report on stakeholder perspectives on Copiapó water management issues. A report submitted to AusAID as part of the study: 'Copiapó River Basin – Analysis study of shortfalls in water rights, industrial usage and social requirements' from the Minerals Down Under Flagship, CSIRO.
3. Trefry, M. , McFarlane, D., Moffat, K., Littleboy, A. and Norgate, T. (2012). Copiapó River Basin Water Management: Terms of Reference for Future Governance and Research Activities. Report to AusAID and Chilean stakeholders from the Minerals Down Under Flagship, CSIRO.

Executive summary

In conjunction with the Chilean government, CSIRO is carrying out a short AusAID-supported project to investigate water management issues in the Copiapó Basin in the Atacama region of Chile. The project's aim is to develop the terms of reference for a larger study of basin management which may prove to be a useful case study that could be applied in other Chilean basins.

As part of the scoping study, CSIRO scientists visited Chile in May-June 2012 and Chilean water managers visited Australia in September 2012 to observe water management systems in the Murray Darling Basin. This report outlines similarities and differences between how water (and to a lesser extent, land and vegetation) are managed in Chile and Australia, using the Copiapó and Murray Darling Basins as respective applications of these principles. This report does not attempt to identify superior models of management.

Chile has a centralised system of government with most important water and land planning and management decisions being made at the national level. It also has strong local management of surface water irrigation at both the individual irrigation canal and at the sub-basin (Vigilance) level. It currently has limited ability to manage water at a basin scale.

Water licensing, monitoring activities and investigations are carried out by the national government's Dirección General de Aguas (DGA) within the Ministry of Public Works. Extensive work on the water situation in the Copiapó Basin that has been undertaken by the DGA and consulting groups has been summarised in English by McFarlane and Norgate (2012). The DGA has limited powers to reduce water licenses (except in emergency circumstances), to undertake basin-wide planning and to investigate illegal water diversions.

In the Copiapó Basin there are two main irrigation groups – a Vigilance Group for mainly surface water irrigators growing export table grapes in the upper and middle basin and a groundwater irrigators group (CASUB) covering olives, pomegranate and vegetable irrigators in the lower basin. There is limited interaction between these two groups and also with the agency responsible for providing town drinking water suppliers and the mining companies located in both the upper and lower basin.

Rapid expansion of mining and the consequent increase in town populations has placed water resources under extreme pressure in the past fourteen years, a period of below average rainfall and runoff.

Chile's 1981 Water Code was developed when surface water irrigators were the principal focus. As a consequence the current management structures supported by this legislation are less well aligned with the current complexity of basin-wide management and the need to accommodate all water user groups, including groundwater users whose recharge relies on streamflows reaching the lower basin.

There are currently over four times more annual water rights issued in the basin than there is water available to meet them. Actual water use exceeds recharge by about 70 per cent and groundwater levels are falling in all aquifers in the lower basin. Trading is the main mechanism expected to reallocate water between users with disputes being mediated through the civil courts. However, this system can be expensive and slow. Not all water rights are registered and not all trades are communicated to the DGA.

Australia also has problems of over allocated irrigation systems and environmental assets being impacted by a dry climate and the need to reduce diversions. There has been a lot of basin-wide planning to address these issues but it is difficult to get all groups to agree on an equitable water allocation plan. As in the Copiapó Basin, river water in Australia does not always reach the lower parts of the Murray Darling Basin, causing problems for downstream water users and environmentally important wetlands.

Several differences are evident in a comparison of the approaches in these two countries to water management. Major decisions are made much more centrally in Chile whereas water management is mainly carried out by state governments in Australia. There has been a move to adopt a more standardised national system in Australia under the 2004 National Water Initiative (NWI). Strategies such as the

allocation of environmental water provisions, basin-wide planning of natural resources and (increasingly) charging water users for water management have become common features of the water management landscape in Australia but such measures have been less prevalent in Chile.

What is common, however, is that both jurisdictions have sought to use trading as the main means of apportioning water between user groups in order to avoid the need for government to intervene. Accurately defining water rights, separating water from land and ensuring that trading does not result in third party impacts (e.g. communities, business, the environment) are important issues that the governments in both countries are seeking to manage.

Also in both countries, government, irrigation groups and farm businesses have invested in improved water efficiencies as demands have grown at a time when the climate has been unusually dry. This has reduced downstream return flows and lowered recharge of aquifers. In some cases these reductions in available water are not well handled by the current water licensing systems. Unused water rights have also been traded to new users which has increased extraction from the systems. Reducing water entitlements in over allocated systems, especially those allocations which are unused, is a policy dilemma for water managers in both Chile and Australia. A lot of the Australian Government's investment in water use efficiency works is condition on the return of part or all of these water savings to the environment as this is a public good that can justify government intervention.

Mines in both Australia and Chile require secure access to water of the right quality to be productive. There can be less flexibility for mines compared with some agriculture and even town water supplies where there is more discretionary water use. In Australia mines can get access to the water that they require through volumetric licenses (rather than capacity share licences) and sometimes specific acts of parliament. In Chile they often purchase water licences much in excess of their annual needs to increase the likelihood of a secure supply. Increasingly they are also desalinating seawater as aquifers are depleted.

In some respects, both nations are trying to get the balance right between public and private interests but coming at it from different positions. In Australia the government is attempting to increase the role of the private sector. The strong individual water rights afforded to holders of water rights in Chile, and the slowness of the legal system in resolving disputes, has resulted in calls for increasing the Chilean Government's ability to manage water on behalf of the public interest, especially in stressed and complex areas such as the Copiapó Basin.

The Australian Government has been involved in industry restructuring to help water users that are impacted by reductions made in available water due to environmental and climate change considerations. The capacity of the Chilean Government to adjust entitlements, except in emergency situations, is less certain.

Some aspects of water management that were of interest to Chilean water managers visiting the Murray Darling Basin included a comprehensive water information system and catchment models that took account of interactions between surface water and groundwater resources. Likely impacts of future climate change in Australia were also able to be estimated and their impacts evaluated.

Based on this comparative analysis of the water management experience of both Chile and Australia, it is felt that both countries could benefit from continued interactions between their scientists and water managers involved in basin projects. In particular, the Copiapó Basin provides a most instructive case study for evaluating promising future options for successful basin-wide management in the Chilean context.

1 Introduction

The project entitled '*Copiapó River Basin, Chile – analysis study of shortfalls in water rights, industrial usage and social requirements'* was funded jointly by AusAID, part of the Australian Government's Department of Foreign Affairs and Trade (DFAT), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Dirección General de Aguas (DGA) within the Chilean Ministerio de Obras Públicas. The project is being conducted between 1st May and 30th November 2012 including two trips to Chile by Australian water scientists and a return trip by Chilean government officials.

An **outcome** of this AusAID-CSIRO-DGA project is to:

'*Produce a preliminary integrated assessment of industrial, agricultural, environmental and social water use profiles and demand projections for the Copiapó Basin which will be a crucial starting point for future water technology integration/optimisation and management tools. Preliminary assessments of the hydrological and hydrogeological resources in the Copiapó Basin, together with preliminary assessments of water regulatory framework and stakeholder perspectives on water management and water needs must also be produced'*.

The **output** being met by this report is a **'***Preliminary Summary Report on the current Water Rights Framework – developed in collaboration with Chilean government, incorporating legislative, policy and economic aspects of water management and comparison with leading regulatory practice, identifying broad gaps and inefficiencies'.*

This report examines aspects of water rights in Chile and makes comparisons with the Australian experience where considered useful. It draws upon material in the literature and also from observations made during field trips of Australian experts to Chile and a return trip of Chilean water experts and managers to Australia. To provide a focus, aspects of catchment water management that are most relevant to the Copiapó Basin are given preference. This comparison with water management issues in the Murray Darling Basin in Australia was a key motivation for undertaking this project. It is an outcome from a 2010 visit by Chilean water managers to Australia. Aspects of managing hydroelectric power are not reviewed as they are not relevant to either the Copiapó or Murray Darling Basins.

The report is a summary that is intended to support a set of terms of reference for a more comprehensive analysis of the Copiapó Basin as a case study for water management reform in Chile. As such the areas reviewed are necessarily brief and targeted to the issues of greatest relevance in the Copiapó Basin.

This report is input into a '*Final Activity Report and Terms of Reference which will be developed in collaboration with and endorsed by key stakeholders including am Inter-Ministry CSIRO Project Advisory Group'*.

The report's structure is as follows:

Chapter 2 provides a high level review of relevant legislation in Chile and Australia and the policies and regulations that flow. **Chapter 3** uses the Copiapó and Murray Darling Basins as examples of how this governance and legislative framework result in water management approaches in the two countries. Gaps and inefficiencies (as required under the project terms of reference) are identified in **Chapter 4** before conclusions are reached in **Chapter 5.** Some findings have been reached through the exchange of experts between the two countries but they are also based on references which are listed in **Chapter 6.**

2 National water governance, policies and management

2.1 Chile

Chile's legislation and governance framework was inherited from Spain although it has been modified in many ways since independence from Spain was declared in 1818. Water management reflects the administrative framework in Chile which consists of 15 regions (numbered I to XV including a metropolitan region instead of Region XIII) and 54 provinces Figure 1.

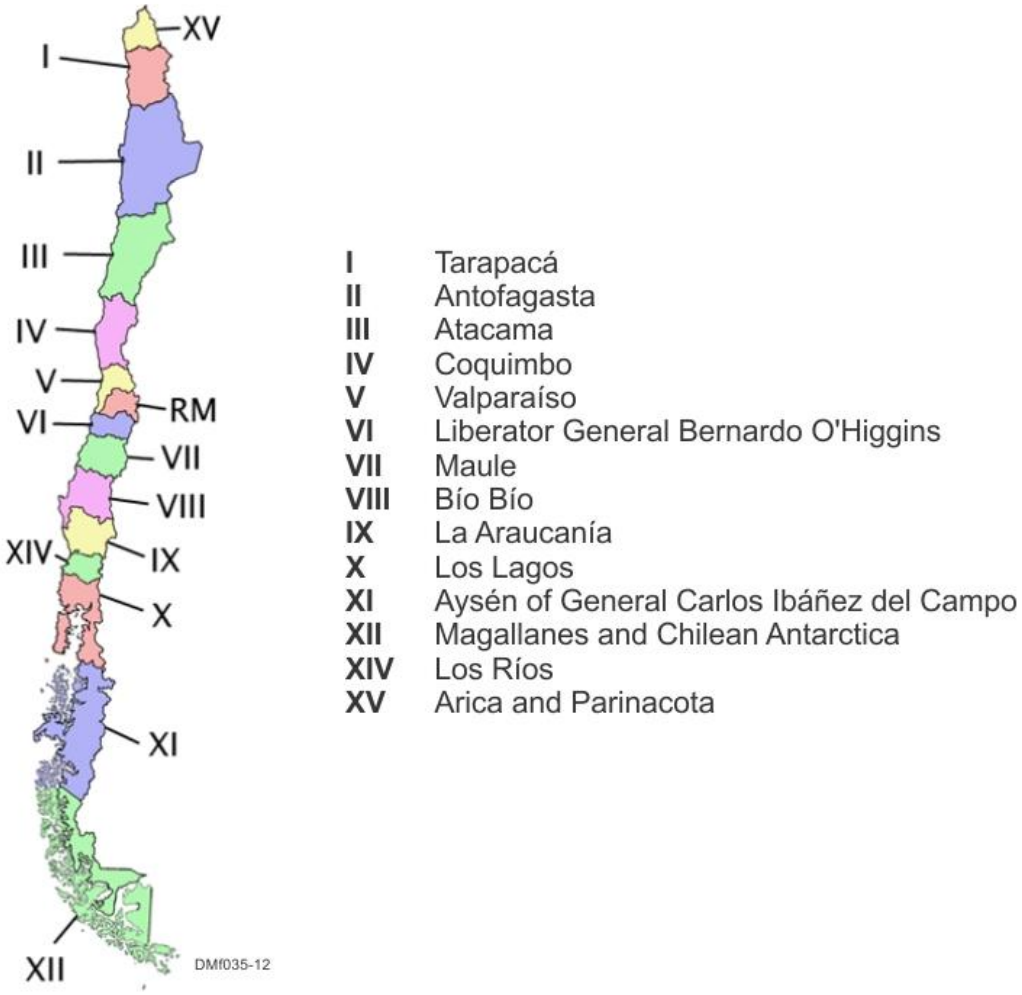

Figure 1. Regional framework for Chile. Atacama is Region III; RM is the Metropolitan Region around Santiago

There are three provinces within Atacama (Region III in Figure 1 above): Chañaral in the north, Copiapó in the centre and Huasco to the south. These provinces are largely based on river basin boundaries making the administrative structure align well with surface water management. The head of each region is the Intendente or Governor appointed by the President of the Republic of Chile. This centralised system means that these appointments are liable to change whenever there is a change of President. Each province in turn is divided into communes – there being three in the Copiapó Province – Copiapó (City), Caldera (a city on the coast) and Tierra Amarilla (a town immediately east of Copiapó). The leader of each commune is

termed an Alcalde, who has both judicial and administrative functions. In Copiapó this is the Mayor who is directly elected for a period of four years.

Chilean Government water policies and planning are managed by the General Directorate of Water Resources (Dirección General de Aguas) or DGA which is located within the Ministry of Public Works (Ministerio de Obras Públicas). Regional DGA staff carry out important monitoring, communications, compliance and liaising roles within each region but policy development and most important decisions are made in the DGA head office in Santiago. This reflects similar roles in national government departments within Chile. This results in consistent decision making across the nation but loses the advantage of developing site-specific solutions to local land and water management problems.

Chile has a Water Code that commenced in 1951 after which there are several important reforms: 1) in 1969 the agrarian reform expropriated all water rights (art. 95); 2) in 1979 water rights were granted to everyone actually using water (with DFL 2.603 as a preview of the code – Carlos Ciappa pers. comm.. 2012); and 3) in 1981 by the government of then President Augusto Pinochet.

The 1981 Water Code did several very important things (list assembled from comments made by Bauer (2004), Bjornlund & McKay (2002), Hearn and Donoso (2005) and DGA (2012a)):

1. Separated water rights from land ownership, a reform that pre-dated similar moves in Australia by more than 30 years;
2. Strengthened private water rights, some of which had been removed by previous national governments;
3. Created market mechanisms to foster a market orientated approach to water. This emphasised the economic value of water over other values such as social, cultural and environmental;
4. Substantially reduced the role of government in water resource management, regulation and infrastructure development. It was assumed these roles would be carried out by the market. While disputes could be adjudicated by the civil courts, the possibility of appeals could also result in lengthy and costly delays in making decisions;
5. The role of the DGA was defined as issuing 'rights of advantageous use' of water but once created these rights are governed by civil law. Private organisations of surface water irrigation canal users were given powers over water use and management as they were the major water users in 1981;
6. If a resource was identified by a potential water user the DGA was given a time limit to assess and issue water rights to the resource or show reason why rights should not be issued;
7. Other roles of the DGA included gathering and maintaining hydrologic data, inspecting works such as dams and canals, enforcing (but not making) the rules governing private water use associations, keeping official registers of water rights and carrying out studies and writing reports. However the DGA was not given powers to enter properties to monitor compliance with regulations or the ability to negotiate basin-wide solutions to water sharing disputes;
8. Emergency powers were provided to the DGA but any reduction in water rights had to be made proportional across all water rights holders and be limited to a six month period unless extended; and
9. Owners of water rights were not required to pay fees or taxes on their entitlements.

Importantly, the private property rights defined in the 1981 Water Code are also embedded in the 1980 Constitution. A condition of the return to civilian government in Chile in 1990 was that the Constitution not be altered, effectively making these water rights much stronger than in other national jurisdictions (Bauer 2004).

In Chile water rights are treated equally, independent of when they were granted (i.e. no 'Doctrine of prior appropriation' or 'first-in-time; first-in-right' considerations as in parts of the USA). However the way that water is managed can greatly influence the ability of a water rights holder to get access to their water entitlement as is illustrated in a later section on Copiapó.

To discourage speculation in water rights in Chile there is a small but rising cost ('patente') for holding water entitlements if the owner doesn't have works to divert or extract the allocated water. The amount is set to double every five years until it reaches four times the initial charge. In 2013 the charge will be twice and it will reach four fold by 2017. At this time it is expected that people who are holding water rights with no works in place to access them will either resign their rights or transfer them to actual water users.

For water users with diversion works in place (the vast majority) there is no cost of holding water rights. There is therefore no cost of holding rights indefinitely or income for government from rights holders for investment in improved water management. If the value of rights are expected do rise with time as demand increases there is an incentive to hold onto rights rather than to trade unused water.

There is a national Irrigation Directorate (Comisión Nacional de Riego or CNR) within the Department of Agriculture which supports the irrigation industry and coordinates irrigation infrastructure works where required. The 1981 Water Code considered a large role for the private sector in building new irrigation systems as they became profitable but many developments still depend upon public funding support as is the case in most countries. The emphasis of the CNR is more on large irrigation schemes and growers than on small (subsistence) irrigators.

The framers of the Water Code did not properly consider groundwater users (especially those that are impacted by surface water use and vice versa) or allow non-irrigation water users such as miners and town water suppliers to be part of water use associations (canal user associations, Vigilance Committees). While groundwater was not a focus of the Water Code, the DGA has considerable discretionary powers in times of declared drought and in approving water transactions that require a change in river flows (Hearne and Donoso 2005).

Master plans have been developed for some water basins in southern Chile but they have no legal or regulatory authority (Hearne and Donoso 2005). These authors have also noted that the reason why water markets have not been institutionalised in most valleys or used to reallocate much water around Chile are: 1) high transaction costs, 2) cultural linkages between land and water, 3) the continued high value of water for irrigation, and 4) the urbanisation of irrigated land. The costs associated with the trading of water rights are included in the titling of unregistered rights, information costs, costs to modify infrastructure and the opportunity costs of time invested in the transaction. It is also the case that farmers often retain surplus water rights in order to mitigate against the risk of drought. However as there were no taxes on retaining unused water rights at that time there was no penalty for maintaining surplus rights.

Hearne and Donoso (2005) identified the key challenges in the Chilean context to be:

1. Development of a fair and just system of incentives to ensure that unused non-consumptive rights do not inhibit investment and growth
2. Improved coordination between consumptive and non-consumptive rights users in reservoir management
3. Increased capacity to resolve conflicts between users
4. A single comprehensive registry of water rights ownership
5. Improved environmental protection including standards for minimum water flows and ambient water quality.

Hearne and Donoso (2005) also identified that the advantages of water markets are not limited to areas of trading. For example the creation of water rights and a system for reallocation negates the need for developing an alternative reallocation system. In the Chilean context they also considered that externalities between users in water user (canal) groups could best be addressed within group norms. In this system, an appeal to the strict (legal) defence of rights would be expected to produce less economic benefit to society than a negotiated settlement. Sectoral water management needs to evolve into a self-rectifying system of integrated water management without the need for expensive and slow court cases. Finally, the lack of an authoritative and complete registry of water rights remains a constraint on the functioning of markets and an impediment to the introduction of any new tax on water use.

Since 1981 there have been some important reforms to the Water Code. A series of amendments to the Water Code in 2005 required the DGA to consider the environment when establishing new water rights,

discouraged water hoarding and speculation by requiring a fee to be paid for any unused water rights, limited requests for water rights to genuine needs and gave the President the ability to exclude water resources from economic competition when in the public interest. Only water rights issued since 2005 are required to address these environmental considerations, however. In many parts of Chile, there are already significant over allocations in water rights. For example in the Copiapó Basin, there are over 600 GL/y in issued water rights (with about 200 GL/y being used) but annual water yields are only about 129 GL/y (DGA 2012b).

The inability of the DGA to do substantial basin-wide planning and management (especially with regard to dispute and conflict resolution among water users) and to allocate water for environmental purposes for water rights that were issued prior to 2005 has highlighted deficiencies in the Water Code in parts of Chile that are under acute water stress, including Copiapó. With limited powers in these areas there is also a reduced scope for the DGA to advance relevant skills and capacity. These challenges were one of the underlying reasons why staff from the Chilean Government visited Australia (in 2010 and in August 2012 as part of the present project) to see how another jurisdiction has approached the problem of joint surface water and groundwater over allocation in a basin with competing agricultural, municipal and mining water demands.

In keeping with this renewed focus on environmental flows, the Ministry of Environment (previously the Comisión Nacional Del Medio Ambiente or CONAMA) has a role which complements that of the DGA in matters of environmental water management. The Ministries current emphasis seems to be on preventing point source contamination by mining and secondary industries through environmental impact assessments and monitoring of compliance (e.g. an important environmental protection agency role) more than a broad national nature conservation role or consideration of non-point sources of pollution such as intensive agriculture and sewerage. The Food and Agriculture Organisation have written a document on watershed management for CONAMA and reported that it was difficult to get all water users involved (Kiersch and Roman pers. comm. 2012). The canal user groups functioned well on a small scale but there was a very limited role for the public sector in basin-wide management. Kiersch and Roman (2012) felt that the management plans that they developed had not resulted in major changes.

Water service providers (water supplies, sewerage and drainage) to towns and cities in Chile are governed by the Superintendency of Sanitary Services (Superintendencia de Servicios Sanitarios or SISS). There is also a peak body for sanitary services utilities, ANDESS (La Asociación Nacional de Empresas de Servicios Sanitarios A.G.). Water services have been largely privatised but a number of water suppliers are still owned by the national government while being required to act as private companies. Aguas Chañar provides water services in Copiapó under such an arrangement whereas the water supply ands sewerage services in Santiago are fully privatised. This difference may reflect the relative profitability of providing water services in urban and regional settings. There is no ability under the current legislation to provide priority allocations to drinking water in water planning.

The most recent analysis of water issues in Chile was made by the World Bank (2011). They identified the following fourteen challenges:

1. Protecting the water rights of vulnerable groups including indigenous groups and small farmers. A significant number do not have titles or they have not been recorded in the real estate register used in trading.
2. Improving the protection of ecosystem water requirements. By the time that provision was introduced in recent legislation all water in the north and central parts of Chile had been allocated to consumptive uses.
3. Improving water markets. Markets remain informal and lack transparency resulting in large price dispersions, additional transaction costs and information asymmetry between market participants that can lead to an inequitable redistribution of water.
4. Maintaining the security of water rights as a result of climate change and reduced return flows (in streams and to aquifers) due to changes in irrigation efficiencies. When there is insufficient

streamflows to meet all demands there may be conflict between users. There are also a lack of user organisations for groundwater resources

5. Water rights need not be used effectively. Changes have reduced monopoly distortion of the market and hoarding of unused rights.
6. The sustainable use of groundwater in over-allocated and over-used aquifers. Despite legislative reforms in 2005 there remains a lack of good information, tools and knowledge of groundwater resources. Also groundwater and surface water resources are not jointly managed. Illegal and legal extractions are not well managed, drinking water sources are not safeguarded and subsidised irrigation technologies can result in reduced recharge and aquifer contamination.
7. Water quality needs to be better protected. While urban and industrial pollution has been reduced, diffuse pollution remains a challenge. It is necessary to improve monitoring networks, increase the understanding of aquatic ecosystems, increase staff in regional authorities and the DGA, and develop management instruments.
8. Improve the public register of water rights. The process of regularisation and refinement of water rights is costly, complex and long and not enrolling does not incur any penalties. Real Estate agents and water users rarely transmit changes to the DGA and therefore the register held by the DGA is incomplete.
9. There is a need to strengthen the DGA in resources (staff budget) as well as its degree of autonomy so that it can make tough decisions.
10. Strengthen user organisations (Vigilance and Canal groups). Less than half are registered with the DGA and they have limited organisational training and professionalism. They also don't represent the whole basin, all water users or there is little participation by some groups in decision making.
11. Improve information and communications systems, especially to do with water conflicts, economic studies and an analysis of policy options.
12. Coordinate intra- and inter-sectoral water use. There are enormous interdependencies between water users and the resulting externalities are unable to addressed in the current system of management. The DGA's level in the institutional hierarchy does not correspond well with its functions. Critical information is often fragmented and not shared between institutions.
13. Watershed management needs to be integrated and stockholder participation encouraged. The DGA's role is currently limited to determining the availability of water, granting new rights and declaring areas of restriction or prohibition. Current stakeholder participation is limited due to a lack of forums for discussion.
14. An improved ability to resolve conflicts. User organisations and the courts are used to resolve conflicts over water. User organisations don't cover the entire country or all users of water. They are also involved in resolving conflicts in which they have a direct interest. Because there is a lack of specialised courts a large number of unresolved conflicts reach the ordinary courts which lack the expertise to properly adjudicate.

A number of these issues are similar to those raised by Bauer (2004) and Hearne and Donoso (2005) indicating that legislative amendments in 2005 and 2010 may have improved some aspects of water management, there remain on-going issues.

2.2 Australia

Australia is a federation formed in 1901 from six separate British self-governing colonies[1]. Under the Constitution the powers to manage land and water resources were retained by these states. Though at the

[1] Australia also includes the Northern Territory and the Australian Capital Territory

start of the twentieth century, the need to provide for navigation on boats carrying agricultural commodities resulted in some early interstate agreements on river management and policy to jointly manage rising river salinity levels, it has only been comparatively recently that nationally-consistent approaches to water management have been implemented.

The Australian and state governments meet regularly to coordinate legislative reforms and service delivery across Australia. Collectively they are called the Council of Australian governments or CoAG. In 1994 CoAG agreed to separate the governmental powers of water management from that of water supply provision. Most residential water services were (and still are) provided by state and local government entities operating under business principles and there was a potential for a conflict of interest if the water manager was also a water supplier in competition for water resources with other water users such as irrigators or industry.

This need to manage water in the Murray Darling Basin, which crosses four states and the Australian Capital Territory, was also an important driver in water reform in Australia. There was an urgent need to have a common definition of water access rights (entitlements) and the separation of water rights from land titles, in part to allow water to be traded across state boundaries. Developing a system that met these needs provided standard water management principles at the national level. These reforms were part of an Intergovernmental Agreement called the National Water Initiative (NWI) agreed through CoAG in 2004(SEWPaC 2012).

Even though the states developed different approaches to water management according to drivers such as droughts and the need to develop irrigation schemes, their legislation is based on British law and there are many commonalities although these diverged over time. Of prime importance is that water resources are vested in the Crown (i.e. owned by government) and it is the access to water that is licensed. This access has been in the form of a time-limited right to divert surface water or to pump groundwater on an annual volumetric basis, often with conditions attached. This has enabled the states to adjust entitlements, often when a plan or investigation is carried out and usually at the end of a designated license period. An important reform of the NWI has been to separate (or unbundle) the rights, and to clarify when entitlements can be altered and when compensation may be payable for the loss of access to a previously held entitlement. Additionally, entitlements are increasingly going to be defined as a capacity share of a regularly determined consumptive pool which takes into account environmental water provisions.

The approach to the provision of water for the environment has differed between states, over time and often between surface water and groundwater resources. Thus environmental river flows were often recognised before the need to protect groundwater dependent ecosystems. In earlier periods dams and wellfields were often constructed with little thought for the environment that, if built now, would require stringent investigations and allowances. Retrospective environmental provisions are being made by state authorities in most cases.

Water resources are formally identified and licensed once they have been developed to such an extent that conflict may arise. Thus licenses may not be required where there is only a small amount of the resource in use. In some areas and states groundwater pumping did not require a license whereas surface waters were regulated. This resulted in resource substitution when surface water flows were low and farmers drilled bores that accessed aquifers that were connected to streams. The interconnectedness of the two resources became apparent and licensing systems are now being developed to manage both resources.

Another interaction that was not immediately apparent was the role of return flows providing water for downstream irrigators. This also occurs with groundwater users pumping from unconfined aquifers. A common response to water shortage is to reduce wastage which means that tail water drains return much less excess water to streams from irrigated fields. Similarly more efficient use of groundwater by irrigators results in less recharge to aquifers. Investments in water use efficiencies therefore often result in less water available to allocate in the system and the need to reduce entitlements to retain an overall balance.

An issue in both Chile and Australia is how to manage water entitlement holders who are not using all or any of their entitlements. Periodical users of water are called ‘dozers’ and those that have not used their entitlement are termed ‘sleepers’. Highly allocated systems benefit from people who do not use their entitlements. The introduction of water trading can activate these entitlements holders making the over

allocation problem worse. One policy that has been adopted in some Australian states (e.g. Western Australia) has been a 'use it or lose it' approach. On the basis that the entitlement holder has not required the water for their business of personal needs the water could be used more productively by other users or for meeting environmental needs. This policy is controversial as it can result in water wastage by entitlement holders wanting to retain their property right. Prudent water users often hold entitlements that are larger than their annual need as a protection against drought. 'Cleaning up' water licenses by identifying actual water users can be attempted by governments as a prelude to commencing groundwater trading in highly or over allocated areas. In Western Australia only water entitlements that have been used at some stage can be traded. This is to discourage water users from applying for water entitlements that are in excess of their business needs and then trading these for profit without developing the project for which the licence was granted. The fact that in some states it costs nothing to obtain and hold water rights makes speculation attractive. When applying for new water rights, users have to specify what they intend to do with the water so that water is allocated to real businesses rather than to speculators. The NWI requires states to recover reasonable costs of water management from users through their licenses.

The relative security of water entitlements can vary in parts of Australia. For example in the Murray Darling Basin, high security entitlement holders receive water before general security entitlement holders in times of supply short fall. In some states there is only one level of security and there is no discrimination between users who have held their entitlement for a long period or those that have only just received an allocation. This is different to most USA states where the order of obtaining the right is also the precedence of having their rights met if water is not sufficient to meet all demands. The trading value of high security water with a high probability of the entitlement being met is much higher than general security water in highly or over allocated systems. The Australian Government is buying back some entitlements in the Murray Darling Basin on the open market to increase environmental allocations in floodplain wetlands and to help meet Adelaide's water needs, recharge the Murray lower lakes and to keep the outlet to the Southern Ocean open. Increasingly under the NWI there is an entitlement position that splits water access rights between the entitlement and the annual allocation in Australia.

3 Application in River Basins

3.1 Copiapó

The Copiapó Basin has six management zones (Sectors) with surface water providing most of the water to users in the upper four zones and groundwater being the predominant source in Sectors 5 and 6 (Figure 2). Sector 4 uses a combination of surface water and groundwater as the alluvial aquifer becomes more extensive away from the river channel in this part of the Basin. Water use in Sectors 1 to 3 is mainly for export table grapes and use in Sectors 5 and 6 is mainly for olives, pomegranates and vegetables, town water supplies and mining (McFarlane and Norgate 2012). Sector 4 has a mix of uses between those of Sectors 3 and 5.

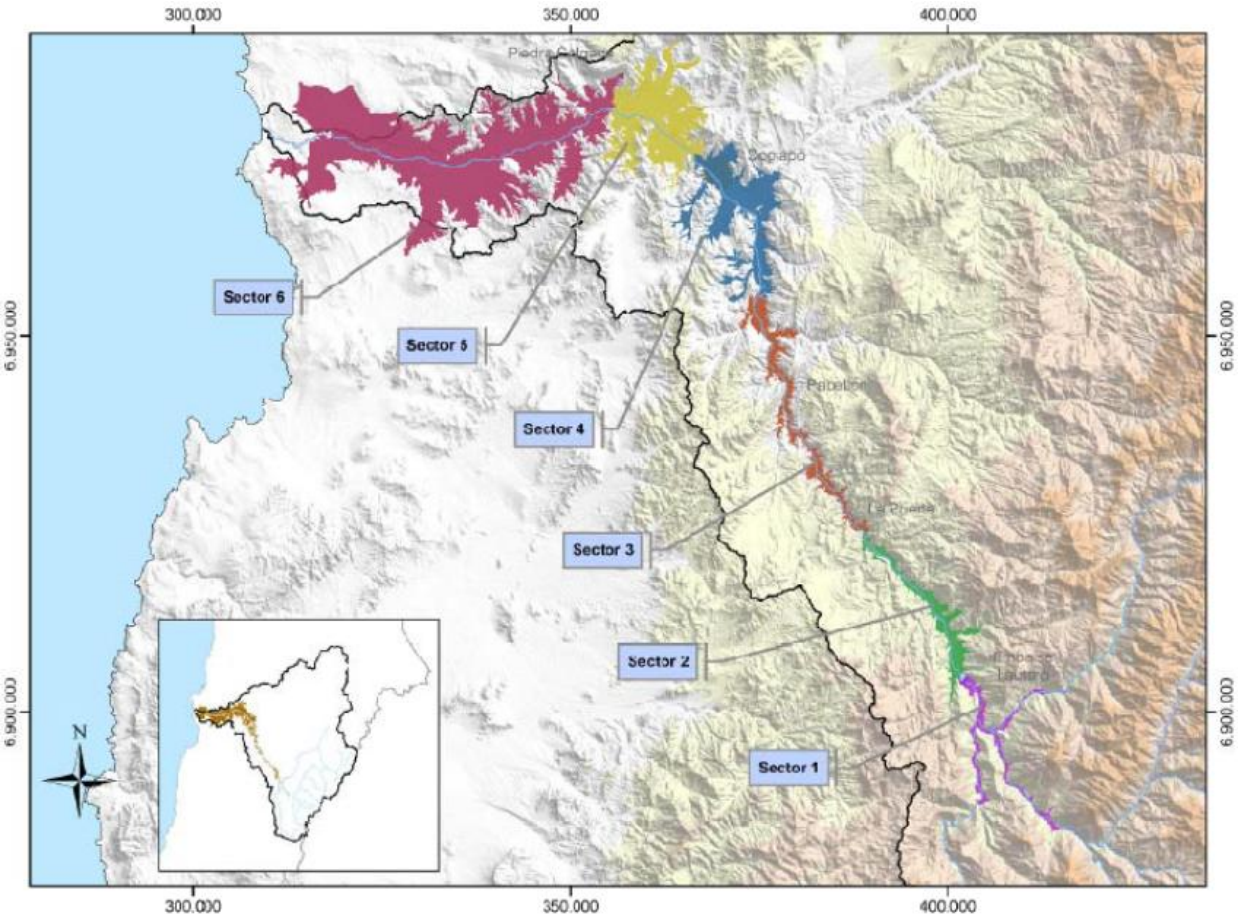

Figure 2. The six management sectors in the Copiapó River Basin showing the width of the alluvial aquifer around the main river channel (DICTUC 2010).

River water is diverted from unregulated streams in Sector 1 while river flows are regulated below the Lautaro Dam in Sectors 2 to 4. Canal groups manage the water in each sector and there is a Vigilance Group for coordinating water in the upper four sectors. Groundwater use in Sectors 5 and 6 are coordinated by CASUB (Comunidad de Aguas Subterráneas de Copiapó). Currently there is limited coordination between the water managers in the upper and lower parts of the Basin (Carlos Ciappa pers. comm.).

Recharge to the aquifers in Sectors 4, 5 and 6 requires river flow which results in recharge from the river bed to the alluvial aquifer shown in Figure 2. The Basin receives less than 30 mm of rainfall per annum in this area so no direct recharge from rainfall is possible. There has not been river flow past Copiapó City since 1998 so aquifer recharge in Sectors 5 and 6 has been negligible in the past 14 years. In Sector 4 the

river channel has had to be diverted into a concrete canal to ensure that it does not leak into the underlying aquifer. While this benefits surface water irrigators it removes a source of natural recharge for groundwater users. Holders of groundwater rights in Sectors 4, 5 and 6 have therefore been using water from storage and this has resulted in greatly reduced groundwater levels and poor quality water. If not replaced it is a form of mining historical recharge and the groundwater resource becomes a non-renewable resource like copper.

If irrigation water is used with high efficiencies (low leaching fraction), salts can build up in the root zone of plants and make the soils unsuited for cultivation. In stakeholder interviews conducted by CSIRO in May - June 2012 it was mentioned that salts are indeed building up in root zones and affecting plant growth.

Further to this, Aguas Chañar has had to source drinking water supplies from Sectors 5 and 6 after wells in Sector 4 dried up. This, along with mining extraction, has further increased pressures on these aquifers.

There is no provision in the Chilean water legislation that allocates water to specific uses but the geographic location of surface water irrigation in upper parts of the Basin appears to be advantaging those upper water users over those with equivalent water rights located lower in the Basin. This is not uncommon in irrigation schemes (e.g. there have been similar experiences in the Murray-Darling Basin as detailed below) but the absence of a basin water strategy and a management group for all water users in the Basin appears to be exacerbating these inequities in this catchment.

The 1981 Water Code places an emphasis on the timely allocation of water rights by the DGA if water can be demonstrated by a user to exist, even if this is only during a wet period. The inability to reduce allocations in dry periods results in a gradual 'ratcheting up' of allocations until areas are over allocated. In Copiapó this over allocation is now more than four-fold. As a result there is reference to 'wet water' and 'paper water' rights indicating different degrees of water availability and/or reliability.

After a period of severe water restrictions in 2007 a Water Negotiation Table was formed of water users to develop solutions that involved all water users (Bitran *et al*. 2011). Despite some success in reducing water rights in Sectors 3 and 4, and water users getting to hear and learn about other users' perspectives on the issue, the process ultimately failed. A new Water Table (or similar) is being proposed to address the current water shortage.

In June 2012 there was some speculation about water being illegally diverted in Sector 1 but there is no provision for the DGA to enter and check water use under the 1981 Water Code. Bitran *et al*. (2011) indicated that all sectors have problems with illegal extraction.

Irrigation infrastructure in the Copiapó Basin is substantially funded by large irrigators with some assistance from the CNR. The Lautaro Dam was mentioned as the last major investment in capital works by the Chilean Government by several interviewees.

Trading in the Copiapó Basin would be expected to solve some of the water issues if the 1981 Water Code was working as intended. Some trades (or temporary 'swaps') have occurred, especially between irrigators and miners until the 2007 shortage resulted in most mining companies deciding to seek desalinated water solutions. Aguas Chañar has also purchased water rights to meet the growing demand for water in rapidly-growing Copiapó city. However concerns were raised by farmers that miners and Aguas Chañar are able to buy water at much higher prices than they can and this will result in the region losing its agricultural industries. It is unclear whether some ageing smaller farmers would be keen to move out of agriculture if they could get a good price for their water, and indeed, for those near the city, for their land. This would help alleviate the land shortage in the narrow valley around urban areas and appears to be a win-win solution for land and water management, and for urban and rural participants. There appears to be little interest in rural adjustment or financial resources to restructure low profit agricultural industries in Chile compared with Australia (see below).

3.2 Murray Darling Basin

Historically the Australian Government invested heavily in the development of the Murray Darling Basin (MDB) in terms of diverting water from the catchment for the Australian Alpine region where a disproportionate amount of runoff is generated into the MDB. They also invested in many dams to increase water storages in areas suited to irrigated agriculture. Over an eighty year period the Basin developed into Australia's main agricultural area and attracted many towns and industries. It is currently managed through the Murray Darling Basin Authority (MDBA 2012). CSIRO carried out an analysis of the likely impact of future climate and development on surface water and groundwater availability in 2030 in the Basin (Figure 3). Drainage from the NE and E of the Basin accumulate in lakes to the SE of Adelaide before discharging into the Southern Ocean.

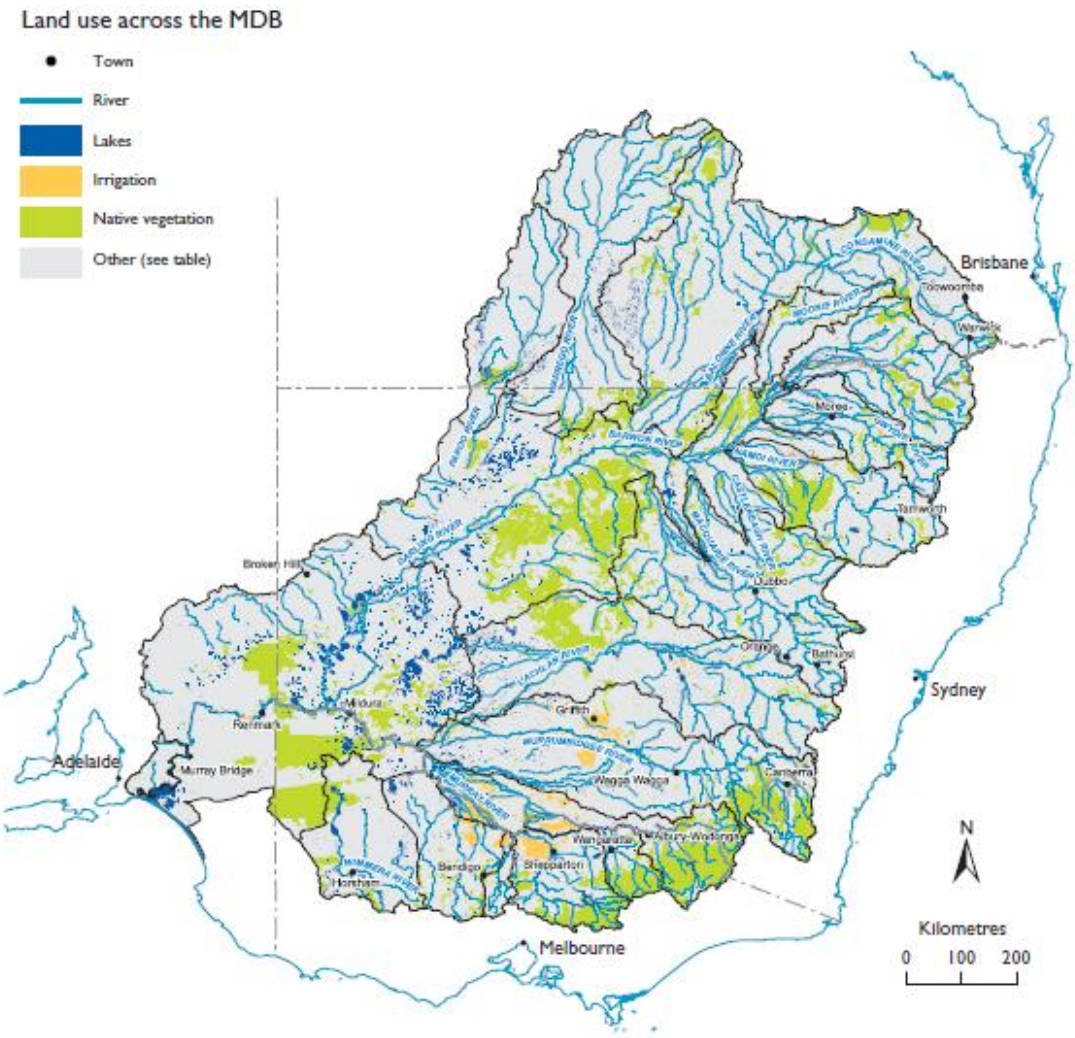

Figure 3. Land use across the Murray-Darling Basin (CSIRO 2008)

The standardisation of the way that water access rights are defined, and separation of water access rights from land, facilitated water trading between farmers, states and irrigation districts.

The development of upstream irrigators such as in the tributaries to the Darling River in Queensland resulted in tensions between upper and lower Basin irrigators. South Australia, being located at the end of the river system and relying on water for Adelaide (population 1.2m), especially felt the impact of upstream

water diversions and drought periods. There are some similarities between Copiapó City and Adelaide in that river flows and water quality issues affect both municipalities, if on a different scale.

Irrigation districts expanded in the MDB in a period of relatively high water availability and water rights were issued which in many catchments are now considered in excess of sustainable levels, especially if important floodplain wetlands are to be retained. The MDB population and agricultural industries rely on reliable water supplies and the Millennium Drought in particular (1997 - 2009) resulted in many farm and supporting business being adversely affected (SEACI 2012). High water using crops such as rice and cotton were no longer grown, some perennial crops were destroyed and irrigation efficiencies had to be further increased. Many river red gum (eucalyptus) communities were also severely affected.

There has been a long history of water planning in the MDB both at the local, catchment and whole-of-basin scale. Current planning is attempting to resolve the amount of water that is available for irrigation and environmental needs, and how irrigation districts may be restructured to better bring their water demands into line with availability, especially after the experiences of the Millennium Drought which affected many industries and businesses. The proposed Basin Plan is an Australian Government instrument being developed to cap extraction of all water resources across the Basin The Australian Government has been purchasing water from irrigators and also allowing environmental water to be traded to maximise the impact of environmental water in times of drought and abundance (as at present).

Irrigation cooperatives manage most irrigation districts in Australia. Irrigators are shareholders with different voting rights according to the articles of association of each cooperative. The cooperatives are developed under commercial law and do not have constitutionally-defined powers like irrigation canal groups have to some extent in Chile.

Water services to municipalities are managed by quasi-government agencies in Australia. In some states (Western Australia, South Australia) the state government controls Government Trading Enterprises (GTEs) which operate under an act that requires them to behave as commercial entities earning a return on capital for their investors (the state government). In other states (e.g. New South Wales, Queensland) there is a much greater role for local government with the commercial water services provision being linked to local councils but required to operate as a commercial business. In all cases they hold a license which effectively provides them with a 'natural monopoly' for a defined period. Opening up water services to the commercial sector is mainly occurring through tendering for the provision of ongoing maintenance services or to build and operate new services such as water treatment or desalination plants. In many regards Australia has not proceeded as far with the outsourcing of water services as many European countries.

Australia and Chile share the impact of the El Niño-La Niña (or ENSO) climate system. However the cycle is not clear in the Copiapó Basin which is affected by several rainfall factors other than ENSO. For example the Copiapó Basin had low rainfalls during some of the years that the Millennium Drought affected Australia. The Atacama Desert experiences very low rainfall in almost all years and it is rainfall in the high Andes that influences river flows. Rainfall and streamflow gauging in this topographically complex area may not be sufficient to detect subtle seasonal changes.

The majority of the area in MDB catchments is used for dryland agriculture, towns and nature conservation. Irrigation cooperatives only manage water and drainage issues in their portion of the catchment. Australia has a history of natural resource management planning and management that has been done a various scales (farm, local catchment, large catchment and sub-basin) but in the past 20 years has been funded by the Australian Government especially at the large catchment scale. In the MDB these management bodies are usually called Catchment Management Authorities (Natural Resource Management Boards in South Australia). Their focus is on managing vegetation, riverine environments and land degradation problems such as dryland salinity, erosion, eutrophication, management of native bush and sometimes flooding. They are statutory bodies in some states and their powers vary. In Victoria and South Australia for example they can raise money by rating properties in the catchment. There does not appear to be a similar level of planning and management in the Copiapó Basin in Chile but non-statutory catchment planning and management is in evidence in some basins further south.

3.3 Brief comparison between the Chilean and Australian systems

Table 1 summarises how water and natural resource management issues are managed in the Chile and Australia with an emphasis on the Copiapó and Murray Darling Basins.

Table 1. How water and natural resource management issues are managed at different scales in Chile and Australia with Copiapó and the Murray Darling Basin used as basin comparisons.

Scale / Issue	Chile	Australia
National	Dirección General de Aguas (DGA) – national management role in water but powers are limited	Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) – national coordination and funding role National Water Commission, providing research and policy advice especially on implementation of the national water reform policy
State / Region	Atacama region – limited role in water management	State water departments – major water planning and management roles
Basin – water allocation planning and management	Vigilance Committee coordinates irrigation water use in the upper basin. CASUB in the lower basin	Murray Darling Basin Authority (chaired by Australian Government) coordinates over all river operation and irrigation systems
Basin – natural resource management	No group	Catchment Management Authorities / Boards often with sub-regional, catchment or landcare groups at lower levels
Irrigation district	Canal groups	Irrigation cooperatives
Water service provision to towns	Privatised water service providers, some like Aguas Chañar are still quasi-national government bodies	Government trading enterprises attached to state or local government with many services contracted out to the private sector

Each structure reflects the history of Spanish and British colonisation. The Chilean system is more centralised with most water, natural resource management and environmental decisions being made by the President or by direct Presidential appointments at the departmental, regional or provincial level.

Being a federation of Australian states, the Australian system is more decentralised although the powers of the Australian Government have greatly increased in resource management areas in recent decades. This has arisen out of a need to standardise systems as once-isolated water management areas are becoming increasingly linked either physically or through the economy.

The Australian water governance system is also more complex with many players able to influence outcomes at different levels. The need for consultation at several levels can slow decision making as the Murray Darling Basin plan is showing at present. In terms of natural resource management, there doesn't appear to be an equivalent body in the Chilean system, but neither is there the same scale of interstate-trans-boundary water systems.

Water use by mining companies can be different to that by agriculture and towns. Mines may have a requirement for water for a specified time period (the life of the mine) and the location of the demand can change over time as mines open and close according to markets and ore grades. Mines below the water

table can also require licenses to extract water that it not for consumptive use and also to dispose of any excess water into the environment. Annual agricultural crops can vary their plantings to take account of seasonal water requirements and towns can introduce water restrictions in times of scarcity.

Under the Australian National Water Initiative it is proposed that water licences progressively move away from volumetric licenses (with a very high degree of reliability) to being a share of the consumptive pool to take account of the seasonal variability in the size of the available resource. Mining interests are keen to maintain the historical system of a volumetric licence with a very high reliability, even if this does not result in the resource being used to its optimal capacity. Mining is often a high value user of water and restrictions on use which resulted in lost production was not supported. It is also relatively common for state governments to guarantee water and land access to mining companies wanting to invest in an area (e.g. through State Agreement Acts in state parliaments). This provides a degree of security as a means of attracting and maintaining large investment projects. It is then up to the government to guarantee access to water.

Mine water security in Chile is met through the purchase of water licences in excess of that which may be required. This can result in accusations of water hoarding and of pushing up the price of water to such a degree that other water users are priced out of the market. Given the degree of over-allocation in the Copiapó Basin it is usual for mine water use to be much less than the water rights that are held. Declining groundwater levels has resulted in companies realising that holding rights for 'paper' rather than for 'wet' water is not a guarantee of accessing water of suitable reliability or quality. Therefore there has been a heavy investment in desalination plants.

This report outlines similarities and differences between the two countries but makes no attempt to identify superior models of management.

4 Broad gaps and deficiencies

The project brief requires that broad gaps and deficiencies be defined for the Copiapó Basin.

4.1 Technical

Technical gaps and deficiencies are detailed in McFarlane and Norgate (2012). Broadly these are:

1 The amount and nature of precipitation in the high Andes and the nature of runoff mechanisms is not well known. How, and whether the upper and lower basins are hydraulically connected is uncertain. Understanding precipitation and runoff mechanisms may help understand how climate change and sequences of below average precipitation may affect runoff into the Reservoir.

2 It is unclear what quantity of runoff, and period of bed inundation would be required to fill the aquifer in Sector 4 and then those lower in the Basin. The nature of surface water – groundwater interactions may have changed as a result of aquifer storages being lower than previously recorded by measurements. It is possible that the nature of streamflow through Sector 4 has changed as a result of dewatering of the aquifer and future small flows will infiltrate through the river bed and fail to reach Sectors 5 and 6.

3 An investigation of the impact of irrigation of low quality water on soil properties and plant growth may indicate whether long term damage is being done to soils as a result of using poor quality groundwater and using low leaching fractions to improve water use efficiencies.

4 The feasibility of converting agricultural land to residential land near Copiapó City could be investigated as this would help reduce the current shortage a building land and reduce groundwater extraction in Sector 4 at the same time. It would provide funds for farmers wanting to exit agriculture at no cost to the government.

5 It is unclear how many water rights are being used and whether they have been traded between user groups. There is a lack of clarity between water rights, (met and unmet) demands and use in the current statistics. Also, having an estimate of the value of water used in each industry (e.g. the gross value produced per ML of water used) would assist understand the highest value uses of water over time and whether the market is reflecting these values.

6 Understanding water use and returns for small, medium and large irrigators would be useful for understanding the impact that may result from a failure of surface water and groundwater supplies or the whether supplies from alternative sources would be viable.

7 While water consumption data has been provided by mining companies to DGA, regular public reporting of such data including all water sources (fresh water, seawater, desalinated water, reclaimed water) and amount of water re-used/recycled with each being reported separately, not aggregated, would be useful in providing some consistency between data sources and be of value in assessing water availability issues.

8 Similar to the JRI Engineering study (carried out to establish a database of tailings properties to assess the suitability for paste thickening), a similar study could be carried out to establish a database of ore suitability for direct processing with seawater, as opposed to desalinated water. This would allow mining companies to decide if the desalination option was required.

9 To help identify where the maximum benefit of water use lies, it could be useful to carry out a study to determine the economic value ($/m^3 water) of the embodied water in the various products produced for export (minerals, metals, table grapes, etc.) in the Basin.

4.2 Legislative and compliance

While powers to charge water users for water management, to undertake basin-wide planning and management and to ensure compliance with users' legal rights are currently weak in Chile, there are moves to strengthen them, especially for water rights holders who do not have works for diversion. While these are nation-wide issues, their effect is being felt in the Copiapó Basin with its severe shortage of water and the rapid pace of development.

The provision of a publically available and up-to-date register of who owns water rights in different parts of the Basin could also improve water trading and management. The current system in Chile uses real estate agents and canal groups but it is unclear if they are working efficiently. On-line systems to put water buyers and sellers into contact with each other are used in Australia and other parts of the world. In the stakeholder consultation there were reports of individual farmers approaching miners about buying their water so that they could retire but with no record of who owns water and whether they are fully using their entitlements this may be an inefficient process. The lack of accurate metering is an issue worldwide which makes it hard to enforce compliance with conditions as well as to develop strategies to reduce over use.

Some jurisdictions require approval before a water trade can be carried out in order to manage any inadvertent consequences on third parties. In irrigation districts the approval of the group may be required before trading water out of a district as there may be impacts on system performance and viability. A trade may also have social impacts in the form of employment or environmental impact. Groundwater trading of extraction towards environmentally sensitive areas or areas where interference between wells is a problem may also need to be controlled. In Chile there seems to be good communications within canal groups but not between these groups and other parties that may be impacted. Trading water between basins (e.g. Huasco to Copiapó) is an example of a decision that may impact on interest groups other than just the buyer and seller of the water. A balance may need to be established between private water rights and public interest in trades, especially if the externalities need to be paid for by another party.

Currently there seems more emphasis on point source pollution (e.g. individual large industries, especially mines) and less on non-point source pollution (e.g. farmland, urban drainage). It is common in many jurisdictions for these two types of threats to be disproportionate to the response. Partly this is because point source pollution is easier to address, especially if the polluter is highly profitable as is most mining. Tackling nitrogen sources in agriculture and on-site sewerage systems is often more difficult.

Chile is a country that is 4,200 km long in the north-south direction with an average width of 180 km. As such it spans many climate zones which makes the development of uniform policies difficult. Developing a solution to a problem in the wet southern part of the country where most people live can result in perverse outcomes in the north. Some similar difficulties were apparent in developing the Intergovernmental Agreement underpinning the National Water Initiative in Australia where the western regions had more emphasis on groundwater, the needs of miners to a temporary source of water or for dewatering (unlike irrigators) and the impact of climate change.

4.3 Socio-economic

Based on interviews with key stakeholders, there is a lack of understanding between user groups and other stakeholders, exacerbated by a lack of available information regarding water allocations and uses. Significant misconceptions between groups emerged from the interviews, potentially fuelling poor levels of trust between stakeholders.

This lack of trust and understanding is something that is common in both Australia and Chile but the mechanisms and resources available to overcome them seem greater in the Australian context. The Water Negotiation Table may be reconvened by the DGA with lessons about what worked well and what caused it to fail being addressed in this version.

In the Australian context, there has certainly been a recent shift in thinking toward the idea that changing the way we manage water resources is perhaps less about the resources themselves and much more

concerned with people and the way they behave (Australian Government 2007; Boully 2004; Boully & Dovers 2002). In recognising the key role that water stakeholders play in the defining and shaping water management systems, raising awareness of the water situation in the Copiapó Basin seems critical. There needs to be agreed facts so that any differences can be better identified and addressed with additional investigations and discussion.

The possibility of housing expanding into nearby farming areas could be explored as this could reduce land prices, provide money for farmers to retire and reduce the amount of water needed for irrigation.

Further detail of the water stakeholders in the Copiapó Basin and a summary of their perspectives are provided in the accompanying report by Moffat and Lacey (2012).

5 Conclusions

In some respects the Chile – Australia comparison is between water law and resource management approaches that have arisen from governance and legislation arising from Spain (Chile) and England (Australia). However each country has developed their own ways of managing water as a result of their histories.

In Chile's case the Water Code (1981) and the 1980 Constitution strengthened private property rights in response to previous governments' nationalisation of land and water rights. At that time there was also an interest in allowing a free market, classic economic approach and the legal system to manage water resource distributions between competing users instead of heavy government intervention.

A 'laissez faire' system of allowing the market to managing water rights exists at one end of the water management spectrum while a system based on complete government control of water rights and users exists at the opposite end. Many jurisdictions are attempting to find the right mixture of private–public approaches to water management to maximise utility.

It is possible that the Chilean approach has influenced how water rights are defined and traded in other countries, including Australia although a much stronger on-going role for government has been retained in Australia. Better definition of private water rights and standardising them between states to encourage water trading was an important objective of the Australian Government's National Water Initiative in 2004. Prior to this initiative, reforms under the Council of Australian Governments (CoAG) had separated water management roles from water provision within state jurisdictions.

The degree to which decisions are delegated to local water managers is also different between Chile and Australia which reflects their historical origins. The Chilean governance system is centralised with political decision making, appointments and policy decisions being focused on the central government, particularly the President who approves government, and regional heads. Australia is a federation of states, each of which retained their power to manage land and water. It is only been in relatively recent years that the role of the federal Australian Government has increased as the need grew to standardise how water rights are defined to facilitate trading in the Murray Darling Basin.

The management of over-allocated systems is been addressed in both Chile and Australia. The legal system in Chile makes the issuing of water rights a government necessity if certain conditions are satisfied. A run of above average rainfall years can make it seem that a long term sustainable water resource is available for licensing. However removing or reducing rights is extremely difficult. This makes overallocated systems almost inevitable and reduces the security of everyone's water right. Through the National Water Initiative, Australia has outlined the conditions whereby water entitlements may be decreased with and without compensation and also indicated the need to move to a capacity share arrangement rather than a volumetric licence. Adjustment schemes have required compensation be paid to holders of Australian water rights but this is less feasible in Chile for financial reasons. Market conditions can result in industries in some Chilean regions failing with little government intervention.

There are signs from recent changes to legislation that both Chile and Australia are slowly moving towards a more similar position in management of water at the basin scale. In Chile's case it is seeking to balance the preeminent rights of individual water holders with increased basin-wide roles of government so that public issues can be better addressed. In Australia's case the change is to allow a greater role for trading and unbundling of water entitlements to increase the role of the market. If this is the case, greater collaboration between the two nations using the Copiapó Basin as a case study may be mutually beneficial.

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