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Copiapó River Basin Water Management: Terms of Reference for Future Governance and Research Activities

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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Contents

Figures

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The Terms of Reference presented in this report were informed by extensive discussions held with a range of water stakeholders in Santiago and Copiapó in May-June 2012, and with the Chilean Water Delegation in Canberra and Orange in August 2012. Final comments were gathered during October 2012 in a further round of discussions with stakeholders in Santiago and Copiapó. All participants in these discussions are thanked for their valuable contributions which allowed the CSIRO Project team to form impressions and perspectives on the complex water governance issues important to Copiapó.

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The CSIRO team expresses its sincere thanks to all the organizations and individuals above.

Executive Summary

This document presents Terms of Reference for a comprehensive investigation into water rights governance and water management options for the Copiapó River Basin, Atacama Region in Chile.

The Terms of Reference were sought by the Dirección General de Aguas (DGA) within the Ministerio de Obras Públicas (MOP) of the national government in Chile. The DGA is responsible for administering the system of water governance and water allocation throughout Chile, and is currently facing a water supply problem in the Copiapó River Basin.

In order to develop appropriate Terms of Reference, CSIRO in partnership with DGA was granted funding by the Australian Government through the Public Sector Linkages Program managed by AusAID. The funding supported a short scoping study performed by CSIRO together with targeted information gathering activities in Chile and in Australia. The output of the scoping study is a set of Terms of Reference for a much larger and longer investigation into options for responding to and avoiding water supply shortfalls and water quality problems in the Copiapó River Basin. It is hoped that these Terms of Reference may represent a blueprint for participatory water management that is transferrable to other basins and valleys in Chile.

The Terms of Reference are directed to the establishment of an equitable and sustainable water management system for the Copiapó River Basin that

(i) is consistent with the Chilean water governance and regulatory framework

(ii) respects the rights, needs and aspirations of a rapidly expanding community in the basin

(iii) provides clarity and certainty to commercial water users (agriculture, mining, water utilities) so that market investment and infrastructure planning is promoted

(iv) can be coordinated and interoperate with national and regional infrastructure planning and investment in the Basin (e.g. energy, transportation, urban development, education etc.)

(v) ensures that environmental values are respected

In recommending change, CSIRO identifies five important principles to guide the change process for enduring impact amongst the basin and its stakeholder: participation, measurement and monitoring, integrated planning, capacity building, and institutional strengthening. These five principles were developed in conjunction with fifteen individual Terms of References for future governance and supporting research activities.

Overall, the report recommends consideration of establishing an integrated basin management plan, supported by appropriate institutional and governance reform (including a review of existing water allocation and trading mechanisms) and developed through a strong and credible participatory process. To inform this integrated planning process, supporting research is recommended in the Terms and includes the development of:

- technical tools to assist water resource planning analysis such as the development of a transparent and integrated water information system, a comprehensive conceptual model of the hydrogeological system operating in the basin and an evaluation of alternative water sources and synergistic water use options;
- foresight studies to look at social and industry trends and develop a shared vision of what the future Copiapo basin might look like;
- cultural and workforce studies that look to safeguard and respect the unique heritage of place in the basin and also equip a new generation of residents with the capacity to manage the basins water in the long term

In identifying these Terms of Reference, CSIRO has identified two key challenges facing the stakeholders of the Copiapó Basin now:

- the challenge to develop a shared, long-term vision for the Basin that will provide direction and goals for subsequent integrated management and planning
- the challenge to establish and operate a modern water information system that aggregates, integrates and publishes regularly comprehensive water use and quality data and reports for all stakeholders

Rapid progress in these two challenge areas is required to underpin the longer process of comprehensive change towards a sustainable future for the Copiapó Basin. A coordinated activity structure and timeline is proposed for the project in Sections 6 and 7 of this report.

These Terms of Reference are supported by background summary reports.

1 Context

• Project Brief

The project entitled '*Copiapó River Basin, Chile – analysis study of shortfalls in water rights, industrial usage and social requirement'* was developed 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 scientists and a return trip by Chilean government officials.

This document presents Terms of Reference for a comprehensive investigation into water rights governance and water management options for the Copiapó River Basin, Atacama Region in Chile.

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The Terms of Reference developed here are directed to the establishment of an equitable and sustainable water management system for the Copiapó River Basin that

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(iv) can be coordinated with and interoperate with national and regional infrastructure planning and investment in the Basin (e.g. energy, transportation, urban development, education etc.)

(v) ensures that environmental values are respected

• Project Process

The project was undertaken in three stages, summarised in Figure 1-1 below.

Out of this process, three underpinning reports have been developed that support the present Terms of Reference:

- McFarlane, D. and Norgate, T. (2012). Summary report on Copiapó water yields and demands. 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.

- McFarlane, D., Trefry, M., Moffat, K. and Lacey, J. (2012). Summary report on the current water rights framework in Chile. 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
- Moffat, K. and Lacey, J. (2012). Summary report on stakeholder perspectives on Copiapó water management issues. Report 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.

These reports have passed internal CSIRO review and have been commented on by DGA, but there has not been sufficient time to pursue a formal public comment process for these reports in Chile. However it is considered that the careful stakeholder engagement process employed in the project, during which these findings were presented to stakeholders, is sufficient to give status to the project summary reports and Terms of Reference.

The present report provides the conclusions from this work.

Figure 1-1: The three stages of the Copiapó River Basin water rights scoping study

2 Present Status of the Copiapó River Basin

In this section we briefly describe the present status of the Copiapó River Basin through five key lenses: demographics, water, regulation, industry (including mining and agriculture) and community.

• Demographics

The Copiapó Basin forms part of the Atacama Region (Region III) and is characterized by extremely low rainfall and mountainous terrain. The Basin supports a human population of approximately 170,000 people currently, but with indications of rapid recent growth likely to continue in the next decades. The economy of the Basin is largely dependent on mining (mostly copper and gold) and also on irrigated export agricultural crops (mostly table grapes and olives). The mining industry draws over 80% of its employees from the local population (although seasonal workforce influxes are common), so fly-in, fly-out methods of work attendance are not widespread. There is impressive public infrastructure in the Basin, including highways and a modern airport, but there is a need for urban renewal in some population centres. Relevant government agencies have recognized the need for urban renewal and some related projects are already in planning and development.

• Water

The Copiapó Basin is presently in a state of acute water scarcity. More water is being abstracted from the Basin by the combined activities of industry (principally agriculture and mining) and community (including water utilities and sanitation) than is replenished by natural means. The best estimates are that 6400 L/s are being abstracted, compared with only 3800 L/s being replenished by natural processes. About 19 000 L/s in water rights have been issued. Over-abstraction has occurred over the past 14 to 24 years, with the imbalance being provided by the groundwater stores of the lower parts of the Basin. Due to the low rainfall and streamflow in the Basin, groundwater is not being replenished, and the groundwater stores are declining as over-abstraction continues. In addition, streamflows are leaking more rapidly from the river bed making the delivery of water in lower parts of the basin problematic. Lower groundwater levels are requiring bores to be redrilled to a greater depth. This decline in groundwater means that the quality of produced groundwater is declining (becoming more salty and high in nitrate and sulphates from agriculture) resulting in significant pressure on ageing pumping infrastructure. The quality decline means that the cost of treating groundwater for potable use is increasing. The result is that the provision of drinking water to the community is becoming problematic, with water restrictions now in place. Environmental water requirements are not factored into water allocations.

• Regulation

The allocation of water rights is controlled by the Dirección General de Aguas (DGA). It is intrinsic to the 1981 Water Code that water rights are vested as property with the land owner, and that water rights may be traded. The purpose of this arrangement is to permit a water trading market to be established so that water can find its highest value use. Past water allocation practices have led to an over-estimation of realizable water rights, so that more water is allocated than can be supplied by the Basin. This is complicated by transfers of allocated rights between market sectors which have fundamentally different usage profiles, e.g. from agriculture to mining, resulting in a biased water trading market that favours high-value uses but does not guarantee sustainability or longevity of the water resource. The Water Code treats all water users equally, so that it is difficult to reduce water allocations unless the reduction applies to all

water users. Emergency provisions in the Water Code have been invoked in order to provide water for the community, but there is significant uncertainty about future water security in the Basin.

There is a key separation of allocation responsibilities in the Basin. The Copiapó Basin Vigilance group manages seasonal water allocation of agricultural water rights that have been issued by the DGA in Sectors 1 to 4. In the lower Sectors, 5 and 6, groundwater only is used and water rights are managed by CASUB (Comunidad de Aguas Subterráneas de Copiapó). There appears to be little integration of the roles and functions of these two bodies, although they each manage aspects of the same water resource. Non-agricultural water users are not adequately covered by these two bodies. The DGA presently does not have the power to inspect premises for compliance of water use according to the relevant water rights, nor does it have the authority to require water use reporting from industry or private water users.

• Industry

The agricultural sector is productive and water-efficient, but operates approximately 12 000 hectares of crops, mostly export table grapes. The agricultural sector accounts for 71% of the total water demand in the Basin. In the Copiapó Basin the mining sector accounts for 22% of the total water use; at a regional scale mining and contributes 49% of the gross product in the overall Atacama Region. Like the export irrigated agriculture sector, the mining sector is also water efficient. Uncertainties about the Basin water supply have prompted some mining companies to make available portions of their water allocations to the water utilities to assist in the provision of potable supplies to the Basin residential population. Some mining companies are also pursuing desalinating seawater at the coast as a water source for their mining operations, replacing or reducing the reliance on Basin groundwater. The energy demand of desalination must also be considered, as the Basin is not a net producer of energy and imports energy from other regions of the country. The agricultural sector is identifying its own strategies and options for water management. It is clear that both the mining and farming sectors cannot solve the fundamental water supply and use issues in the Basin by further incremental efficiency improvements. The water market has also failed to reallocate the available water with inequities in water security between water right holders in the upper and lower parts of the Basin as well as between water user groups. It is now impossible to transfer water between the upper and lower basin via the river channel because it will infiltrate due to groundwater levels being many metres below the river bed.

• Community

The residents of Copiapó Basin receive their potable water supplies from water utility companies. These companies (predominantly Aguas Chañar) are licensed and regulated by the Superintendencia de Servicios Sanitarios (SISS) and are required by law to provide potable water of appropriate quality and quantity to residents. With the declining quality of Basin water resources, drinking water quality has declined and treatments costs are escalating while water security is low. Water utilities are constrained in their ability to recover extra costs by the limited capacity to pay of the residential population and other water customers and there is no concept of priority allocation for population needs, so that population water requirements compete with industrial and agricultural demands. Water rationing occurs within the city of Copiapó and other major centres, leading to community disquiet and extra burdens on consumers. There is particular concern among the residential community about the future of their cities and towns, and of the declining amenity of the urban centres. For example, the Rio Copiapó no longer flows through the city of Copiapó because of the abstraction of water upstream of the city – this is seen by the community as a negative outcome for the Basin. Even so, because of the rapid growth of the mining industry in the Basin, the residential population is expected to grow significantly, and provision must be made for the associated water and infrastructure demands. Previous attempts at community engagement on the water issues have been suspended. Interview results indicate large variances in the perceptions of different stakeholder regarding the value of these prior engagement processes.

3 General Principles for Change

All stakeholders recognize the need for change the way that water is managed for the Copiapó Basin, but despite the best efforts of all involved a coordinated plan for change has not yet emerged. It is the view of the CSIRO team that an integrated Basin Management Plan is required to coordinate and facilitate rational and orderly change in the Copiapó Basin. The following change principles are recommended:

• Participation

The water issues in the Basin affect a wide range of stakeholders, including public and private sectors, as well as the community. Aspects of urban lifestyle and environmental values are important to the community, as well as to governance and regulation. Stakeholders in the Copiapó Basin need to plan for an attractive and sustainable future, so all need to have a voice in the planning process. Participation is not equivalent to an executive function – decision making is ultimately the responsibility of government. However broad participation is important to establish a basis for decision-making, and therefore it is in the interests of all to ensure that a diversity of stakeholders have the ability to participate actively in Basin planning discussions.

• Measurement and Monitoring

The water supply and demand dynamics of the Basin are complex and are not well understood. There are instances of excellent water measurement infrastructure in the Basin, but the standard across private and public sectors is uneven. Management of the Basin's water resources will be facilitated by improved measurement and monitoring systems, and improved analysis and interpretation. It is important for the relevant authorities to measure and report water status and trends frequently and regularly, making the reports easy to understand and freely available. Confidence in the Basin management strategy will grow as the benefits of consistent water status reporting are seen. Early identification of issues will also aid investment planning and help attribute causation to low water levels.

• Integrated Planning

There are encouraging examples of integrated water planning in the Basin, e.g. use of municipal wastewater for mining purposes, but overall the Basin lacks an integrated approach to water management. The goal here should be a comprehensive water plan that balances natural flows and external sources with demands from industry, agriculture, urban demand and environmental requirements. In developing such a balanced plan, account must be taken of water sources, residential population demographics, mining and agricultural trends, energy supply and demand, and transportation and housing infrastructure. Water supports all of these activities; therefore it is crucial that all uses of water are coordinated to best effect via an integrated planning process.

• Capacity Building

The Copiapó Basin is situated in a unique climatic zone with significant water scarcity. While this is well understood by all stakeholders and has been addressed by boosting the water efficiency of mining and agricultural operations, there is an opportunity to make the Basin community itself more water-wise. Improving general levels of understanding of the water challenges facing the Basin and of the options and strategies for addressing these challenges will facilitate the necessary changes in water management.

Building the capacity and knowledge of all stakeholders will raise the likelihood of constructive debate regarding the future of the basin. Knowledge building and education opportunities include, but are not limited to

- the natural water components and water balance for the Basin
- how the Basin uses, treats and disposes of its water
- residential water quality, pricing and supply
- water-saving technologies (domestic, industrial, agricultural)
- water-dependent ecosystems
- new water sources and consequent infrastructure dependencies
- water governance structures (national/regional, agencies, groups, associations, etc)
- academic and professional education exchange

Strengthening Institutions

In moving towards a goal of integrated and sustainable water management some water management roles may need to be adjusted to define responsibilities and accountabilities. This may also lead to changes in water allocation practices in order to redress the current over-allocation of resources. There is no doubt that the current allocations are unsustainable, even allowing for likely climate changes over the next few decades. Even if external water sources sufficient to meet predicted mining and agricultural demands became available to the Basin, it would take the Basin many years to recover a natural hydrological and environmental state based on annual flows. Therefore water management processes must be strengthened.

Whilst some water data is already being collected by stakeholders in the Basin, e.g. mining companies, agriculturalists and utilities, not all of it is communicated to the Chilean government agencies responsible for water. It is crucial that the Chilean government be in possession of comprehensive water status, water allocation and water use data throughout the Basin so that it can:

- assess regulatory compliance of Basin water users
- report on water status, allocation and use to all Basin stakeholders
- develop and maintain quantitative Basin water resource models and systems to facilitate management interventions and forward planning
- contribute this water understanding to a broader, integrated planning approach for the Basin, taking into account population, industry, agriculture, infrastructure and the environment

The Copiapó Basin can be a test case for evaluating new ways of governing water which cut across a number of national government agencies' areas of responsibility. The Intergovernmental group that has started to meet in Santiago needs a similar regional grouping to ensure that the Chilean government delivers integrated advice and services to the citizens and industries in the Basin.

4 Terms of Reference

With the need for change with respect to the Copiapó Basin water issues firmly established, we now consider a series of concrete measures and steps that will provide lasting benefit to the Basin. These measures and steps are designed to assist in the development of a sustainable water future for Copiapó, and reflect the principles for change discussed in the previous section. They are presented as Terms of Reference suitable for developing an integrated program of research, engineering, regulatory, community engagement and other activities required to support a broad, basin-scale management initiative for the medium and long-term.

Although the current water problem in the Basin is well recognised and it is accepted that rapid management responses are required in the short term, the complex interrelationships of processes and actors within the system mean that fundamental and sustainable change will take time to occur. It is fundamental and sustainable change that we focus on here. In pursuing this emphasis we recognize that funding requirements of these management responses must be addressed in terms of the wider national budgeting process. There will be significant scope for instituting efficiencies in resource and infrastructure management through standardization and cooperation. The identification of such opportunities for improved efficiency will be a primary role of the basin-scale management initiative.

• Social Terms

ToR-1 **A Participatory System**

Enduring and sustainable change is achieved through engagement and ownership of solutions. Many nations are looking to concepts of deliberative democracy, dialogue and participation to involve stakeholders in decision regarding contested or complex issues. An effective multi-stakeholder process providing opportunities for all stakeholders to engage and iterate with the evolution of the basin and planning decisions involving the basin is recommended. A carefully reconstituted and restructured Water Table may provide the framework for this process.

ToR-2 **Identifying a 'Chilean Solution'**.

A solution to the water problem in the Copiapó Basin will need to be driven by stakeholders and leaders at different levels from within Chile. There is value in systematically researching Chilean case studies where multiple stakeholders have brokered solutions to complex resource use problems in the past in order to apply key principles underlying this success to the Copiapó Basin and to facilitate the transfer of experiences knowledge between case studies and Copiapó Basin stakeholders.

ToR-3 **Building Stakeholder Capacity**

There is a need to build the capacity of stakeholder groups to participate and negotiate a more sustainable future for the Basin. Utilising a comprehensive stakeholder map and issues register developed through ToR-2 activities, a process to articulate the positions of these stakeholders and build the capacity of these groups to work together (particularly community, Colla, and small agricultural users) will be important to the success of participatory processes implemented. The information platform developed through this participatory process will serve as the basis for broader community education programs, e.g. through mass media and through curricula in the education system.

ToR-4 **Basin Demographic Trend Analysis**

Currently there is no integrated or agreed future preferred state for the Copiapó Basin or understanding of how different population and industrial growth models may affect the resource. Building on the work of FAO in 2010 that began a process to articulate a vision for the Basin, the preferred visions of key Basin stakeholders may be articulated and consolidated to explore areas of agreement and divergence under different growth scenarios for the Basin.

ToR-5 Cultural and Environmental Heritage

In times of change there is a risk that past knowledge and heritage may be neglected. Stakeholder discussions in May-June 2012 indicated this risk, especially in terms of the environmental attributes and cultural values of the Basin. Loss of heritage impacts civic pride, and there were strong opinions voiced that the alteration of the flow patterns of the Rio Copiapó (and other impacts of the recent water use and land use changes) have detrimentally affected the sense of place felt by some parts of the Basin community. Furthermore it is clear that more work must be done to define the present environmental values of the Basin, which already supports a RAMSAR-listed wetland of world environmental significance in Sector 1, and a significant wetland at the river mouth in Sector 6. It is important to understand these environmental and cultural aspects so that stakeholders can make informed choices about Basin planning options.

• Water Terms

ToR-6 A Water Information System

The access of stakeholders to current, authoritative water information in the Copiapó Basin is limited, and this limited access is hampering management and community understanding. The Basin would benefit from a centralized data analysis and reporting system that publically reports data regularly to stakeholders. This need not be expensive if Basin members agree to support a single system of monitoring and reporting. Interpreting these data will then be able to be done by all stakeholders. With supporting technical analyses, a consensus should emerge as to trends and probable causes. Where there are disputes, a means of resolving differences needs to be agreed.

ToR-7 Improved Basin Hydrological Understanding

The present understanding of the Copiapó Basin hydrology and hydrogeology is limited. Useful models have been developed in the past but no up-to-date hydrological model exists for evaluating options. This situation needs to be remedied - a comprehensive model would provide stakeholders with a rational conceptual basis for water resource planning. Technical investigations and scenario modelling have helped evaluate management options in the past and there needs to be continued investment in this area to determine the most cost-effective options for inclusion in the Basin planning process. The interactions between high Andes precipitation and streamflow and between groundwater levels and streamflows needs better assessment as there may be long term trends behind what appears to be natural variability.

ToR-8 Alternative Water Sources

It is attractive to supplement the Basin's limited water resources by introducing external water sources, e.g. desalinated seawater or water transported from further south. The present moves within industry and government to develop these water sources need to be considered in terms of the net economic, environmental and social impact on the Basin and on the areas that may be providing their own limited water resources. Efficient re-use of water for multiple applications, resource recovery from waste streams and the net energy costs need to be considered.

• Industry Terms

ToR-9 Agriculture Trend Analysis

Trends in agricultural water use (currently 71% of the use in the Basin) need to be monitored and reported by groups such as the Comisión Nacional de Riego (CNR) along with farm profitability as changes in land use greatly affect future water demand projections. Crop yields and product quality measurements may provide an indication of water deficiencies and the accumulation of salts in the root zone of perennial crops. Smaller growers of vegetables, pomegranates and olives will be harder to survey but provide data for community welfare monitoring as well. There is also scope for identifying new cropping options and new market analyses, which may provide useful planning options for Basin managers.

ToR-10 Mining Trend Analysis

Mining water use can be expected to increase in the future due to increased production and falling ore grades, although this demand is expected to be largely met by the use of alternative water sources such as desalinated seawater. However, 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 the 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. There is also uncertainty about the amount and fate of dewatering water in the high Andes. Furthermore, it would be useful to establish a database of ore suitability for direct processing with seawater (as opposed to desalinated water). This would assist mining companies in deciding if the need to desalinate seawater is required. Mining companies can also be expected to improve their water use efficiency through the implementation of water reduction technologies such as improved tailings dewatering systems. A benchmarking study comparing water use with other mining operations with similar ore types, grades and processing routes could help identify if further opportunities exist to reduce water consumption.

ToR-11 Urban Water Management

Currently, municipal use is better known than other uses because each service is metered and charged on a volumetric basis. There needs to be clarification as to who owns treated wastewater as it could be made even more valuable with treatment technologies such as managed aquifer recharge. There are a number of hidden costs of supplying low quality water to consumers – e.g. corrosion, scaling impacts on devices as well as chronic public health impacts. An understanding of the willingness of customers to pay for improved water quality or security of supply may be useful in negotiating tariffs in future. As a case study, variable tariffs could be trialled if feasible under the current legislation.

ToR-12 Synergistic Water Use Options

The re-use and recycling of process and mine waters has become a significant means of minimising overall water consumption. Municipal wastewater also has potential for reuse in mining operations and in irrigated agriculture and urban maintenance (e.g. parks and gardens, dust suppression etc.). However, the effect of recycled water properties on plant performance, particularly the build-up of contaminants, must be considered prior to implementing a water recycling process and further work is required to provide this information. This information would assist mining companies and other wastewater users in determining what water treatment processes, if any, are required and help them adapt to the water strategy of using water that is “fit for purpose”, i.e. water quality matched to application, as high quality water is not always required.

• Governance Terms

ToR-13 Governance Improvement

The Chilean Government has the opportunity to strengthen its oversight and coordination of the Copiapó Basin. At the national level, the cooperation between agencies relevant to the Copiapó Basin can be promoted and improved. How State actors interact with Regional counterparts will also be critical to providing the correct environment for successful change in the Copiapó Basin. There may be several governance models and structural mechanisms at State and Regional levels appropriate for fostering the governance improvements required to support change in the Copiapó Basin. These options need to be considered as a priority, as it is the Chilean government that has ultimate responsibility for the management of the Copiapó Basin. This is an important responsibility as the Copiapó Basin has the potential to perform strongly in economic terms into the future. Furthermore, successful management interventions in the Copiapó Basin may well be readily transferrable to other water-scarce basins in Chile, which may lead to increased synergies and efficiencies at a national level. For these reasons it is important that due consideration be given to how best to establish in government a positive energy for change within the Copiapó Basin.

ToR-14 Review of Water Allocation and Water Trading Mechanisms

It is understood that the existing methods of water rights assessments and allocations have not produced a strong water trading market that is able to respond appropriately to water stresses between industries. Large investments have been made in water rights that cannot be translated to actual water usage. This is financially inefficient and has led to a water supply situation where the residential water market faces severe water restrictions and declining water quality. Nevertheless, it is not the water market that is the cause of these problems; rather it is the regulation of the water market and the ability of water to be physically traded in a system with limited inter-connectivity that is deficient. There is distrust between some water user groups about whether water rights are being misused by other groups due to a lack of transparency and enforcement. This situation needs urgent review in order to correct the water allocation distortions and to allow the water trading process to operate in a manner that is consistent with the needs, rights and aspirations of a developing basin.

ToR-15 Integrated Basin Management Plan

The Copiapó Basin problem is not just a water problem. Significant stresses are also being felt in terms of energy, in housing and urban development, and in public infrastructure. Addressing these stresses will take investments by both the private and public sectors. Balancing the financial needs of the Copiapó Basin against other needs within Chile is the task of the State. In order to justify priority in the national investment budget, the Copiapó Basin needs to develop a comprehensive and integrated Basin management plan that

i. maximizes investment opportunities between the public and private sectors
ii. demonstrates innovative and sustainable energy and water solutions wherever possible
iii. provides sound strategies for urban renewal and/or growth for communities in the Basin
iv. builds capacity in education, health and industry
v. has wide stakeholder support

• Summary

A total of fifteen Terms of Reference for future governance and supporting research are presented and discussed. In summary, the Terms of Reference would encourage the following:

- Establishing an integrated basin management plan, supported by appropriate institutional and governance reform (including a review of existing water allocation and trading mechanisms) and developed through a strong and credible participatory process.
- Informing this integrated planning process with supporting research to provide:
    - technical tools to assist water resource planning analysis such as the development of a transparent and integrated water information system, a comprehensive conceptual model of the hydrogeological system operating in the basin and an evaluation of alternative water sources and synergistic water use options;
    - foresight studies to look at social and industry trends and develop a shared vision of what the future Copiapo basin might look like;
    - cultural and workforce studies that look to safeguard and respect the unique heritage of place in the basin and also equip a new generation of residents with the capacity to manage the basin's water in the long term

5 Key Challenges

The previous sections discuss general principles for supporting change in the Copiapó Basin and the Terms of Reference for developing concrete steps and actions to enact change. The principles and Terms were developed in response to several key challenges for the Copiapó Basin identified by the CSIRO team. In this section we list these key challenges and provide some relevant context.

Key Challenge 1: A Shared Vision for the Copiapó Basin

It was apparent from the stakeholder interviews conducted during the May-June 2012 visit that there was no particular move towards integrated planning in the Basin, nor even a widely accepted vision of how the Basin would or could look in the medium to long term. Certainly, there were diverse opinions of what steps could be taken to improve the current situation in certain limited respects, but there was no enunciated vision for the Basin, its resources and its community.

Experience elsewhere suggests that management of any complex basin benefits from clear directions and goals, and that the management task is simplified if relevant stakeholders actively support and promote these directions and goals. The CSIRO team feels that the lack of a shared vision for the Copiapó Basin represents a critical risk for the success of any integrated basin management plan. On the other hand, a cogent and supported vision will provide the essential motivation for all change-related activities in the Basin. The Terms of Reference presented in Section 4 address this key challenge by promoting a participatory approach to understanding the Basin and developing future management options.

There are many possible vision statements that may be suitable in the Copiapó context, and the CSIRO team does not seek to identify or promote any particular vision over any other. The most important point is that whatever vision is selected for the Basin, it must have broad support among the various stakeholder groups in order for the vision to be sustained. Broad stakeholder support will depend on the capacity of the stakeholder groups to engage in positive and structured dialogue.

Key Challenge 2: A Modern Water Information System

The present process for measuring, sharing and interpreting water information in the Basin is patchy and does not have information dissemination as a primary function. Modern technologies simplify the processes involved in measuring, transmitting and storing water information, and there are examples of excellent water information practice within the Copiapó Basin. However, the regulatory framework does not define a statutory role associated with comprehensive water data collection, analysis and dissemination, and there is no requirement for water users to report their water usage and water quality statistics. The net result is that water managers have to base management actions on incomplete and often incompatible water data reports. Furthermore what information is now publicly available is not in an easily used or interrogated form. Since water management depends on ready access to data and interpretation, the current water information situation is hampering planning and development at the Basin scale.

There are many examples of modern water information systems that support publication of information to a wide range of stakeholders (industry, government and community), and much of the technology standards development and systems architecture has already been done. Chile is in a good position to build on these examples to develop its own water information system. Even so, an efficient and flexible water

information platform is only part of the solution. Users must have confidence and incentive to use the system, i.e. submit their water data regularly, and the system must have well understood processes for verifying, storing, integrating, publishing and adding value to the collected data. Establishing such processes and systems may require regulatory adjustments and structural change within responsible agencies, but the benefits will accrue to the integrated Basin management process.

Summary

The two key challenges listed above may be viewed as *enabling* challenges. That is, once achieved they will enable a raft of other developments and changes for the Basin. They also may provide insights and services that are transferrable to other contexts within Chile. Other challenges may be anticipated to arise as the Chilean community adapts to and manages the water problem in the Copiapó Basin in the coming years. However, the two challenges above are immediate and must be addressed in order for Copiapó Basin to access a sustainable future.

6 Actioning Change

Consistent with the Terms of Reference and Key Challenges described in the preceding sections, change can be delivered for the Copiapó Basin by following the steps described below under the major groupings of Growing Participation, Copiapó Heritage, The Basin at Work, and Enabling the Future. These groupings are referred to as Management Programs and are intended to group and organize the many activities and projects referred to by the Terms of Reference.

Program 1: Growing Participation

This grouping seeks to establish and grow a deliberative process for integrated management of the Copiapó Basin. Key outcomes of this effort will include:

- A **shared vision** for integrated Basin management.
- **Greater capacity** for continuing dialogue about the Basin's future.
- Consensus on the composition, status and role of **new participatory bodies** to be involved in the integrated management function.
- Identification of **principals** able to represent and lead interests within a participatory framework.
- Development of a **governance structure** for integrated management that is consistent with Chilean governance at both the regional and national levels, and that is endorsed by peak stakeholders.
- Establishment of a basin **education and outreach program** for community, associations and government.

Program 2: Copiapó Heritage

This grouping seeks to develop and communicate the fundamental information baseline on the heritage values of Copiapó Basin required for integrated management. Key outcomes of this effort will include:

- A detailed **geographical assessment** of the Copiapó Basin, defining the Basin's topography, extent, landforms, land uses, pedology, historical and future climate and cadasters using combinations of geographic information systems and remote sensing to quantify physical aspects of the Basin.
- A detailed **environmental assessment** of the Basin covering flora and fauna (species, abundance, geographic coverage, threats, ecosystems etc), providing an overview of changes occurring over the past 500 years and a summary of the present environmental values and status.
- A detailed **assessment of the social and cultural heritage** of the Basin, identifying aspects of heritage significance, history of population and cultural change, and recording local perspectives.
- An updated and extended set of authoritative **hydrological and hydrogeological models** of the entire Basin that are used by Basin managers in support of decision making, planning and for future scenario analysis regarding water resources, water use and water demand.

Program 3: Basin at Work

This grouping seeks to develop and publish an understanding of how the Basin's economy and community operate today and what the currents trends are. Much of this work already resides in industry associations and in government, but a means to aggregate this information and publish it to all key stakeholders in a consistent format is lacking. Key outcomes of this effort will include:

- An authoritative **water information system** that regularly collects data on water storage, flows, usage and demands within the Basin, which is regularly updated and extended as new information sources become available, and which regularly publishes its findings to stakeholders and the public.
- A detailed **demographic status and trend analysis** for the Basin, including socio-economic analysis, population growth, educational and health indicators etc.
- A detailed **assessment of the current status and trends in the agricultural sector** of the Basin, including all aspects of horticulture, the water demands and water rights ownership, water trades between agricultural water users and with other user groups, the net economic returns to the Basin of the different crops, cadastral data, employment data, transport and other required infrastructure, market analysis etc.
- A detailed **assessment of current status and trends in the mining sector** of the Basin, including all commodities, the water demands and water rights ownership of the mining companies, the net economic returns to the Basin from the different commodities, cadastral data, employment data, transport and other required infrastructure, market analysis etc.
- A detailed **assessment of current status and trends for water supply and sanitation** in the Basin, including domestic housing and public facilities, cadastral data, supplied water quality and flow rates, treatment and disposal of waste waters, recycling/re-use technologies and programs, tariff arrangements, overt and hidden costs of providing low water quality etc.
- A detailed **assessment of current status and trends for urban housing and infrastructure** in the Basin, including urban development plans, investment programs, cadastral data, transportation infrastructure, demands for and availability of schooling, health, recreational and cultural facilities, etc.
- A detailed **assessment of current status and trends for energy supply** in the Basin, including peak and baseload analysis, energy generation/transmission technologies, energy costs and investment, cadastral data, demand management strategies and demand trends, market analysis, etc.

Program 4: Enabling the Future

This grouping is where the collaborative system leverages the Basin information platform to identify, discuss and prioritize options and scenarios for the Basin's future. Key outcomes of this effort will include:

- An **integrated management plan** for the Basin, including water, energy, industry, environment and community factors, under regular review and re-assessment in response to external and internal drivers.
- A continuing **stakeholder participation and communication methodology** for management of the Copiapó Basin.
- A continuing process of **management scenario development and assessment** for input to Basin vision development, management planning and decision-making. Scenario areas include population management, new water sources, new energy sources, new crops and mineral commodities, new water sharing options etc.
- A **clear system of governance** that incorporates dispute resolution, lines of responsibility and authority, and that includes mechanisms for regular review and reform

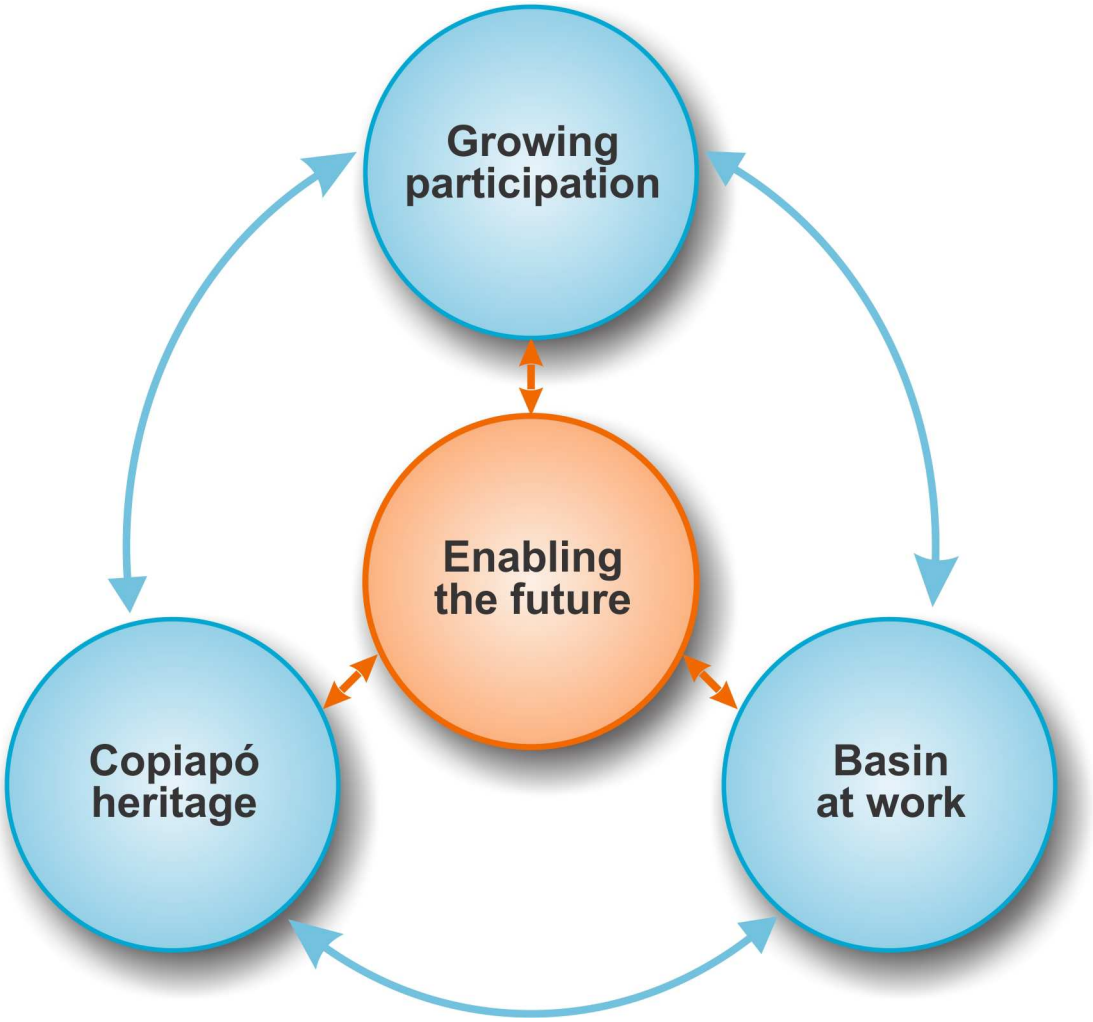

Figure 6-1: Relationship between the four proposed Management Programs for Copiapó Basin

The four Management Programs form a consultative system. That is, there are direct information exchanges between the four Programs. This is important to ensure that all stakeholders have the opportunity to be involved in and informed by the full range of discussions and activities, but also have the option to concentrate their energies in the areas of most interest to them. The focal point of the proposed plan is to enable attractive options for the Basin's future, and this must be supported by constructive contributions from the other three Management Programs.

7 Timelines for Action

Copiapó Basin is in the positive position of having much useful and relevant information already compiled. This means that many of the outcomes of the Copiapó Heritage Program and of the Basin at Work Program can be progressed immediately and rapidly to build the information baseline required for integrated management. However, significant amounts of work still remain to be done in these Programs, and also in the Growing Participation Program.

In Figure 7-1 a schedule for instituting research and management actions is proposed. This schedule is designed to give effect to the change actions as quickly as possible, whilst recognizing that some necessary actions may require longer durations or perhaps, in some instances, best be regarded as continuing processes.

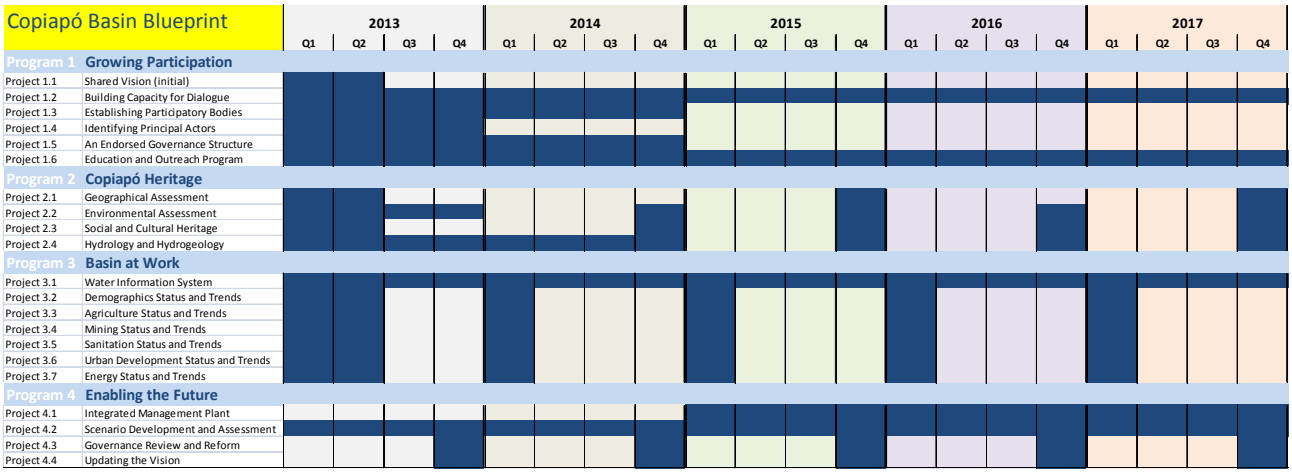

Figure 7-1: Proposed Action Schedule for Copiapó Basin Management

Key features of the schedule include:

- In Year 1, intense focus on groundwork for participation and on information gathering
- Long-term efforts in establishing community education programs, building the water information system, and in scenario development and analysis
- Annual updates of industry trend analyses and of social, environmental and hydrological information
- Annual reviews of the governance framework and of the shared vision statement
- A governance structure for basin planning endorsed and operating after Year 2
- The first pass at an integrated management plan in Year 3, with annual updates thereafter

8 Conclusions

The program of work to action positive change for the Copiapó Basin outlined in previous sections may appear ambitious but there are several factors that make it achievable:

1. The acute water shortage and economic importance of the Copiapó Basin to Chile's economy has meant that it has already had many studies and the work program proposed is in many cases a matter of completing and better integrating existing data, processes and tools. The work will also assist areas beyond the water domain and will help meet general planning needs
2. A number of initiatives are already underway in Chile in improved water management. Copiapó Basin provides an excellent and well-defined opportunity to evaluate and improve these new approaches for subsequent wider and more efficient application elsewhere in Chile.
3. The rapid transition between agricultural and mining industries and workers, and the rapid growth in Basin population, means that new methods could be introduced which may not be possible in a more static situation

These Terms of Reference seek to build upon past work in the Basin and the universal acceptance that there is a need and impetus for change if the Basin is to realise its full potential. The alternative is to risk a situation where water supplies are insufficient to meet demand, with serious impacts on industries, communities and agencies.

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