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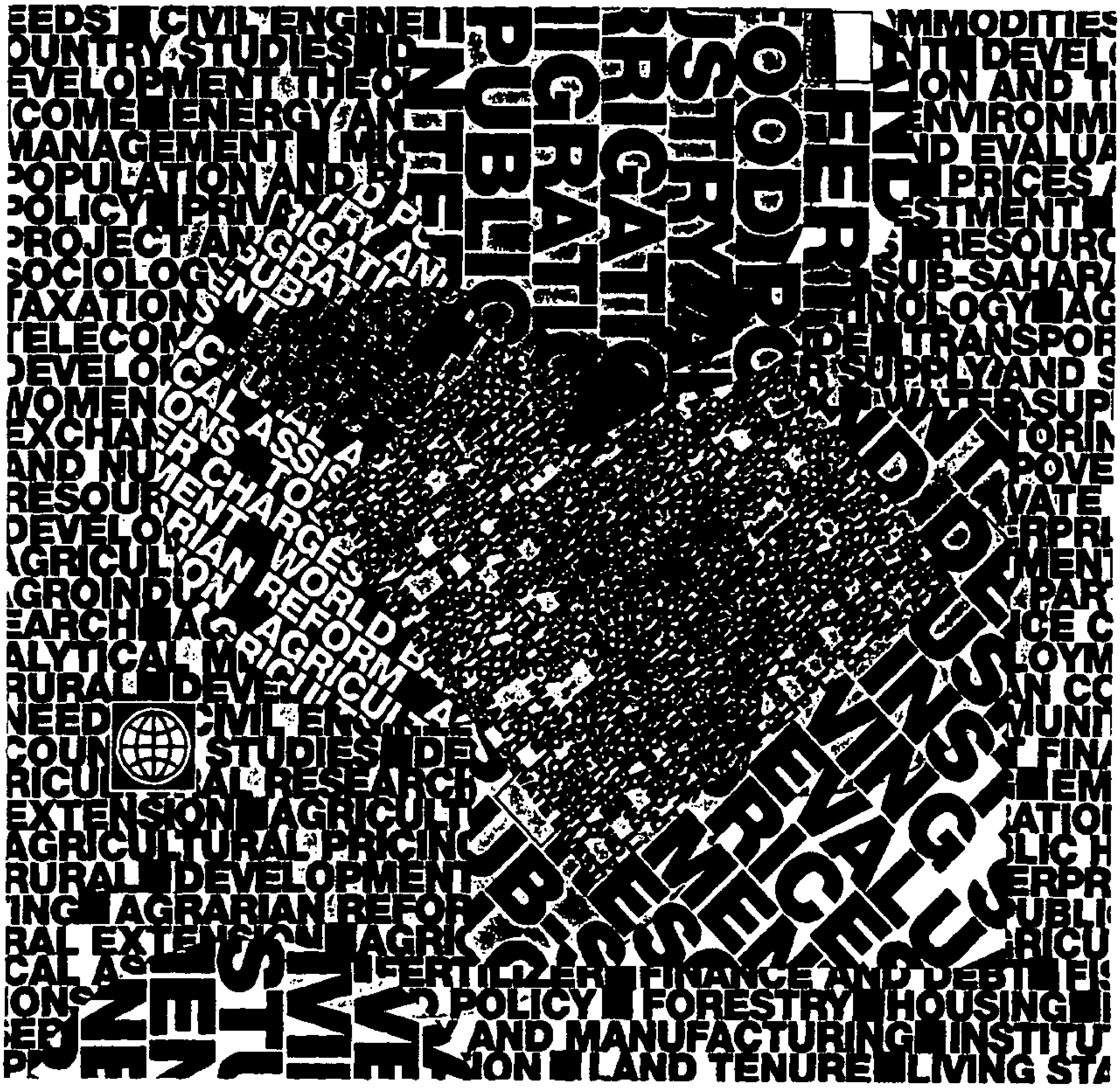
Water Allocation and Water Markets

An Analysis of Gains-from-Trade in Chile

Robert R. Hearne and K. William Easter



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FOREWORD

With the publication of its 1993 policy paper *Water Resources Management*, the World Bank made a commitment to assist developing countries in establishing institutional frameworks and management procedures that would enable countries to utilize their water resources in an economically and environmentally sustainable manner. The impetus for the policy came from the alarming deterioration and increasing scarcity of freshwater resources around the globe, caused mainly by growing population pressures and the failure to properly consider the economic value of water. Usually when water is given little or no economic value, it is misallocated and misused.

This paper is intended to reinforce the World Bank's overall effort to improve the management of natural resources and to highlight the importance of water resources in particular. The Bank's 1993 *Water Policy Paper* and the 1994 technical paper, *A Guide to the Formulation of a Water Resources Strategy*, were the first steps in this process.

The paper focuses on water allocation problems and the performance of water markets in improving allocation. By examining specific case studies in Chile, one of the few countries that has encouraged markets for water, it demonstrates that water can no longer be treated as a free good and better ways must be found to improve its allocation and use. Efficient water markets are one means of improving water allocation, while at the same time providing a mechanism to directly compensate existing water users. In addition, as the market value of water becomes clear to water users, they will use it more efficiently.

The findings in the paper suggest that market transfers of water use rights in the study area produce economic gains both in intersectoral trades and in trades among farmers, and that they produce rents for both buyers and sellers. The extent of trade and the level of gains vary depending on river basin locations, the alternative value of water in present use, water delivery infrastructure and the cost of the transactions.

Our hope is that this paper will encourage professionals engaged in water resources management to adopt practices that produce the desired outputs, but do not have unwanted impacts on the environment. It is important that we give users incentives to make better use of water resources. Without such incentives, the misallocation of water resources will continue and future generations will find their opportunities for water use severely restricted.

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EXECUTIVE SUMMARY

With the growing concern about the increased scarcity and inefficient allocation and use of water resources, attention has been focused on the use of markets to allocate water. Market-based allocation could secure water supplies for high-value uses in urban and rural areas without the need to develop costly new sources of supply that may be environmentally damaging. Also, by requiring compensation for water transferred away from low valued uses, water markets provide an incentive for more efficient water use in agriculture, industry, and municipalities. Furthermore, if markets work efficiently, price signals can provide the information needed to allocate water more effectively than models developed by a central water resources management agency.

Chile is one of the few countries that has encouraged the use of markets in water resource management. The market allocation of water in Chile is possible, in part, because a system of transferable water-use rights was reestablished in 1981. These rights are independent of land use and land ownership. Thus, trades of water rights are not tied to land sales. When combined with flexible irrigation infrastructure such as adjustable gates and effective water user associations (WUAs), these rights can stimulate a relatively active water market in areas of water scarcity.

Given the hope that the market allocation of water-use rights can offer a possible solution to the problems of increased scarcity and inefficient allocation of water resources, this study of water markets in Chile was initiated in late 1993. In order to assess the impact of water markets and transactions costs in Chile, four river valleys, the upper Maipo, the Elqui, the Limarí, and the Azapa were selected as case studies. The sale of water-use rights in the Elqui and Limarí valleys, during the years 1986 to 1993, was analyzed to determine the gains-from-trade from market transfers. In the upper Maipo valley, transactions were rare and were not included in the analysis. Similarly, in the Azapa valley, only a few transactions were identified, and gains-from-trade were not calculated. In the Elqui valley, transactions were infrequent and constrained by the lack of adjustable gates, but there were significant intersectoral transfers as well as a slow transfer of water-use rights within agriculture. In the Limarí valley, with its well-developed system of irrigation infrastructure and well organized WUAs, transactions were relatively frequent.

In the analysis of water markets, crop budgets were used to estimate the value of water in agricultural production. The value of water-use rights to urban water supply companies was estimated using the avoided cost of the next best alternative investment. The analysis demonstrated that the market transfer of permanent water-use rights produced substantial economic gains-from-trade in both the Elqui and Limarí valleys. These economic gains were present in intersectoral trades and in trades between farmers, and they produced gains for both buyers and sellers.

Buyers, especially farmers growing profitable crops who bought water-use rights and individuals buying rights for potable water supply, received higher rents than sellers. Large table grape producers in the Limarí valley and individuals buying water for human consumption in the Elqui valley received the highest rents. In the Elqui valley, total and net gains-from-trade per share (average of 0.5 liters/second) were within the range of recent transfer prices of US $1,000. In the Limarí valley, gains-from-trade of water-use rights were three times the recent transaction prices of US$3,000 for a share (4,250 m^3 annually) of water from the Cogotí Reservoir.

In the Elqui valley, where intersectoral trading occurred, most of the water-use rights transferred out of agriculture were not used by their owners prior to the sale. This means that there are considerable financial gains from these transactions, while the estimated economic gains to society are relatively modest as someone else is assumed to use the water. It is important to emphasize that in this valley, the intersectoral transfer of water involved sales by individuals who were not actively using the water in farming, rather than sales by active farmers selling marginal quantities of water.

These case studies demonstrate the diversity of water allocation systems and water management practices in northern and central Chile. In areas where trading was active, especially in the Limarí valley, transactions costs have not presented an appreciable barrier to trading. Nonetheless, in the large canal systems with fixed flow dividers, such as those found in the Elqui and Maipo valleys, there have been very few transactions. Various factors facilitate trading, but the absence of trading in these large canal systems highlights the costs of modifying fixed infrastructure, especially for trades between farmers.

Water user associations play an important role in facilitating the market reallocation of water, especially in the Limarí valley where trading is active and in the Elqui valley where intersectoral trading occurs. In the Limarí valley, where reservoir storage, adjustable gates with flow meters, and well organized WUAs helped lower transactions costs, the water market is active and gains-from-trade are substantial.

This study has several important implications for other countries faced with water scarcity:

- First, there are significant gains-from-trade that can be realized by fostering water markets. These gains occur in both intersectoral trades and trades between farmers.

- Second, transferable water-use rights are essential for efficient water markets. These rights can be stipulated by volume or by percentage of river or canal flow. But in areas where water supplies are highly variable, it is necessary to agree on how the rights will be altered during times of scarcity.

- Third, great care should be exercised in the initial allocation of water-use rights among users in order to make sure that all the rights are not captured by a few individuals. If the water is to be used for irrigation and an equitable distribution of land and water already exists, a good strategy is to distribute water-use rights to the owners of land on which the water is being used.

- Fourth, technology such as adjustable gates and institutional arrangements that encourage the formation of active water user's associations can substantially reduce transactions costs and facilitate market trading.

- Fifth, the presence of privately held water rights does not necessarily make it more difficult to reach environmental quality objectives for rivers. Water quality regulations need to be established and enforced irrespective of the water allocation system. In Chile, where river valleys are relatively short, the quantity and quality of return flows may be less problematic than in other countries.

- Finally, within a decentralized system of water resource management, there is a continuing role for water management authorities in enforcing rights and resolving conflicts. Yet if institutional arrangements are established that allow water users to resolve conflicts among themselves, they can avoid the need for further government intervention.

Further considerations should be given to:

- Land use patterns
- Urban water use patterns
- Irrigated vs. dry land agriculture
- Water conveyance technologies as constraint on water market transactions
- Irrigation technologies and their role in a water market setup
- Supporting legal and institutional mechanisms to regulate water market activities
- Role of incentive systems for water savings to enhance water market transactions
- Environmental consequences - negative externalities from water transfer (water quality, soil erosion)
- Third party effects - regional employment and welfare

I. INTRODUCTION

With the growing concern about the increased scarcity and inefficient allocation and use of water resources, much attention has been focused on the use of markets in water allocation. This market based allocation could secure water supplies for high-value uses in urban and rural areas without the need to develop costly, new sources of supply that may be environmentally damaging. Also by securing compensation for water transferred away from low valued uses, water markets provide an incentive for more efficient water use in agricultural, industrial, and municipal uses. Furthermore, if markets work properly, price signals can provide the information needed for efficient water allocation more effectively than models developed by a central water resources management agency.

The effectiveness of water markets is constrained by the ability of buyers and sellers to measure and transport water, to legalize and enforce transactions, to account for water quality, and to protect the rights of other water users. Thus, the effect of transaction costs and the infrastructure and institutions that reduce these transaction costs are critical to the effectiveness of water markets. In addition, the unconstrained movement of water via private exchanges can produce negative external effects on third party users. There is also the fear that the free exchange of water may disadvantage poor people.

Chile is one of the few countries that has encouraged the use of markets in water resource management. Market allocation in Chile is possible, in part, because a system of transferable water-use rights was reestablished in 1981. These rights are independent of land use and land ownership, thus trade of water rights is fairly unrestricted. The codification of these water-use rights coincided with a series of reforms in the Chilean economy including privatized land rights and liberalized trade.

Although Chile is unique in its water rights system, the challenges that face its system of water resource management are very similar to those that face other countries. The increased population and income in Chile's urban areas is creating an increase in the urban demand for water. In addition, industrial and residential pollution are overburdening the assimilative capacity of many of Chile's rivers.

This paper presents a description and an analysis of water allocation and water markets in Chile. The first part of the paper provides a brief introduction and theoretical framework. The second part of the paper reviews relevant literature. The third section offers background information on water allocation institutions in Chile. The fourth part of the paper presents a brief description of local water markets as well as an analysis of gains-from-trade. The last section provides conclusions as well as general observations on water policy in Chile. Annexed to this paper is a more thorough description of four river basins used as case studies in this analysis. A second annex presents maps of the valleys discussed. A third annex presents crop budgets used in valuing water for the gains-from-trade analysis. A final annex displays the questionnaire used in the survey of farmers who have participated in market exchanges.

Markets for Water and Water-Use Rights

As an introduction to a discussion of water markets it is useful to distinguish between the exchange of water and the exchange of water-use rights. This is appropriate because the distinction highlights the importance of the institutional environment for water resource allocation. The former — sometimes referred to as a "spot market" — occurs when the owner of a legal or prescriptive right to a certain volume or flow of water sells a portion of that water, sometimes outside of legal sanction, to a neighbor in a simple transaction. These exchanges are for a finite period of time — sometimes only a few hours of irrigation. Although the unit of sales may not be metered volumetrically, both buyer and seller have good information on the volume involved. A more permanent transaction involves the exchange of the water-use right itself. This generally requires legal sanction to maintain the security of the right after the transfer. These transfers are generally permanent, but can be for a finite, but extended period of time — at least one irrigation season. And the burden of uncertain supply will fall on the purchaser of the right.

Water Markets, Transaction Costs, and Institutions

Where water is scarce and legally defined transferable property rights exist, market trades can be expected when the difference in the value of water between two uses is greater than the costs of transferring the water. In the absence of transaction costs economic incentives would induce water users to trade water-use rights until the marginal value of these rights was equal across all users. Of course, transaction costs do limit the movement of water and the transfer of water-use rights. Transaction costs for water market transfers include: i) the cost of the physical infrastructure needed to measure and transport water, including the evaporation and filtration losses during conveyance; ii) the cost of searching and finding willing buyers and sellers, and negotiating a contract; and iii) the cost of validating legal ownership of the water-use right, legalizing the contract, enforcing contract provisions, and acquiring necessary permission from regulatory authorities to transfer water. Because these transaction costs can be large, the number of potential buyers and sellers may be limited — which may result in non-competitive pricing.

In order to reduce the burden of these transaction costs, public organizations can be established to construct water delivery infrastructure, to modify and monitor the distribution of river and canal water, to expedite the dissemination of market information, to maintain public records of water-use rights, and to protect the rights of third parties affected by a transfer of water. These services may be provided by a central government, local governments, or community organizations. Many governments have made large investments in irrigation infrastructure and water management authorities. Although these irrigation systems were not generally designed to facilitate market transfers, the presence of flexible infrastructure should reduce the transactions costs of market exchanges. Also, user groups, especially the water user associations (WUAs) that manage and maintain canals, can play important roles in facilitating and monitoring trades.

Because water use is characterized by a high degree of interdependence, individuals may want to restrict the amount and types of transfers that occur. Changes in the allocation of upstream water and irrigation practices can impose a negative externality on downstream users. The transfer of water away from a canal can increase the percentage of water lost in conduction and evaporation in that canal. An increase in the number of water-use rights flowing through a canal can reduce the amount of water received per water-use right in the canal during times when river levels are high. This is because during high water unlimited withdrawals from the river are permitted, and the only constraint on water delivery is the carrying capacity of the canal. Also, changes in water use can significantly effect water quality. Thus both government authorities and WUAs may want to regulate water transactions to ensure that they are beneficial to the community of water users and society.

II. LITERATURE REVIEW

The market exchange of water and water-use rights is a relatively rare phenomenon, and thus the economic analyses of actual exchanges are scarce. Still, there exists a wide range of literature which addresses issues pertinent to water markets. Unfortunately, much of the relevant literature discusses the water markets of the western U.S.A., but more recently studies have been completed for other areas. There is also a lack of economic research on proper regulatory strategies, methods of reducing transaction costs, and the effectiveness of water markets outside the U.S.A..

Included in the literature is a large number of articles which take an interdisciplinary approach to study the institutions that provide the environment for market allocation. In general these articles review how the prior appropriation doctrine in the western U.S.A. has been modified to provide a well regulated framework for market transfers (Clyde, 1989; Anderson and Leal, 1989; Griffin and Boadu, 1992; Harper and Griffin, 1988; and Schupe et al., 1989). In a 1990 volume pertinent to Chile, Lee traces the development of water distribution systems in Latin America and suggests that water management has been dominated by single purpose government agencies concentrating on the development of large supply projects. He then features four South American case studies, including Chile's Limarí River valley, to describe the organizational difficulties of large multipurpose water systems. In comparison, the case study from Chile is fairly favorable, although the discussion focuses more on the physical characteristics of the system and gives little attention to the institutional concerns in Chile or to market trading.

Along with the literature that explains water institutions, there exists some, mostly non-empirical, economic discussions of water markets and their policy implications. This literature provides a good background of the issues involved with water markets in the western U.S.A. These issues include: transaction costs, hydrological uncertainty, the non-pecuniary value of water, and the "community" value of water (Brajer and Martin, 1989 and 1990); the characteristics of water markets that achieve social welfare (Howe et al., 1986); water quality (Colby Saliba and Bush, 1987; Colby Saliba, 1987); the shadow value of water (Easter and Tsur, 1995); and the rent accruing to water "owners" (Bowen et al, 1991).

A few papers have generalized beyond the experience in the western U.S.A.. Brajer et al. (1989) describes market allocation for the benefit of non-economists, featuring a good discussion of transaction costs and how market imperfection can lead to economic rents. Rosegrant and Binswanger (1992) examine alternative policies to improve water use and environmental management in irrigation and suggest that a market for water-use rights would function well, once water-use rights are established. The authors present a institutional innovation approach to the development of markets — as water prices rise, the institutions requisite for water reallocation will follow.

There are a few empirical studies concerned with the effects of water markets. These studies mainly focus on the benefits of market and administrative transfers of water. In a large study of interregional water transfers within California, Vaux and Howitt (1984) estimate potential annual gains-from-trade for 1980 ($67 million), 1995 ($156 million), and 2020 ($219 million). Chang and Griffin review the water institutions of the lower Rio Grande valley (U.S. side) and estimated the gains-from-trade (ranging from $3,000 to $16,000 per 1000 m^3) for transfers from agriculture to municipal water supply. Dinar and Letey (1991) use a micro-level production model for the central valley of California, and suggest that water markets increase farmers' profits, reduce farmers' use of water — thus reducing the salinity and selenium buildup, and increase farmers' investment in water conserving technologies. Whittelesey and Houston (1984) simulate diversions of water from irrigation to hydrogeneration in the Pacific Northwest and show that the value of water, welfare, and farm income all increase. Hamilton et al. discuss the welfare gains and policy implications of a transfer of provisional water rights from agriculture to a hydroelectric utility in the Pacific Northwest. Maass and Anderson (1978) evaluate the water market in Alicante, Spain, and found that the market system produced greater net increases in regional income than the rotation systems used in neighboring communities.

Another set of articles address water markets and focus on specific policy implications of water trading. Charney and Woodard (1990), and Howe et al. (1990) estimate the effects of rural-to-urban water transfers on the agricultural areas losing water and show that the indirect upstream and downstream effects on rural commercial activity can be significant in highly localized areas. In a simulation of potential California water trades Weinberg et al. (1993) show that although the effect of increased water prices on salinity and selenium accumulation is noteworthy, water markets may not serve as well as a set of well formulated Pigouvian[1] taxes in reducing negative environmental externalities. Colby (1990) investigates the transaction costs required to obtain approval of water transfers and the litigation costs of third party challenges to transfers. She suggests that these institutional constraints can be used as Pigouvian taxes to protect against the negative externalities of water transfers. Colby's estimates of transactions costs average 6% of purchaser's costs for transfers in 4 western states and this is considered not to be a burden. In a fairly detailed analysis, Rosen and Sexton (1993) revisit the transfer of water from the Imperial Irrigation District to the Southern California Metropolitan Water District, and conclude with suggestions of policy reforms that decentralize control over water-use rights.

There is also a limited literature on current water allocation in Chile, although without economic analysis. Two volumes of reports prepared for the National Irrigators Conventions of 1986 and 1989 contain a lot of general information on contemporary water issues as well as many reports on water-use from various river valleys. Gazmuri (1994) provides a good, and very optimistic, review of the primary features of the 1981 Water Code. In a institutional review of the roles of property rights, markets, and the government in water-use in Chile, Bauer suggests that the 1981 Water Code has worked well in the agricultural sector but not so well in intersectoral water allocation. He asserts that private property rights to water have served agriculture well, despite the fact that poor infrastructure, incomplete archives, and a cultural resistance to water sales has limited use of market mechanisms to transfer water. Nonetheless, Bauer (1994) argues that the Water Code has serious flaws in its approach to conflict management, non-consumptive water-use rights, and water quality. Finally, Donoso (1994) reviews the negative economic effects of incentives that could be generated by the proposed use-it-or-loose-it rule on water-use rights.

[1] A.C. Pigou argued that externalities produce a difference between social and private returns, and a system of taxes and subsidies could be used to internalize these externalities.

III. WATER ALLOCATION INSTITUTIONS IN CHILE

In order for market mechanisms to efficiently allocate water between competing uses, institutions must be in place that enable both buyer and seller to obtain fair value in a trade. The most critical prerequisite for markets is a system of transferable water-use rights. Ideally, these rights should specify the quantity, quality, and timing of water delivery. Water-use rights should also specify the criteria by which water is rationed in times of drought. Also, a system of regulations or taxes may be required to protect third parties from damage and to enforce the privileges and restrictions placed on these rights. Finally, a mechanism of resolving conflicts between water users is necessary.

Water-Use Rights

Chile has a tradition of private development of water resources and private rights to shares of river and canal flows that dates to the colonial era. This tradition is maintained in the National Water Code of 1981[2] which allows private transferable property rights for water use. This water law reversed the 1969 water law, written during a period of land reform, which tied irrigation water to the land and mandated state control over water resources.

The 1981 water law stipulates that water is a national resource for public use but that permanent and transferable rights to utilize water can be granted to individuals in accordance with the law. Water-use rights can be granted by the government upon petition, can be purchased from an individual owner, or can be retained based on traditional use. Currently, there is no stipulation that water-use rights must be utilized in order to be retained.

Rights can be defined as permanent or contingent. Permanent rights are granted for use on unexhausted sources of supply. In most of Chile's river basins, especially in the north and in the central valley, all permanent use rights have already been assigned. Contingent rights are granted for surplus water, that is water flows that exceed those demanded by permanent rights holders during times of high water. Reservoir or lake water is not subject to contingent rights since, under most climatic conditions, the regulation of water flow is sufficient to nullify the chance of excess flows of water.

Rights are also designated as consumptive and non-consumptive. Consumptive rights entitle the user to completely consume the water without any obligation to return it. Non-consumptive rights grant the owner the use of the water as long as it is returned to its source at a specified quality, and does not interfere with consumptive use rights. The law stipulates that rights are to be specified by volume of flow per unit of time. But in reality rights are defined as a share of stream flow, because the high variability of natural river flows prohibits volumetric specification. In order to resolve this inconsistency, natural rivers are divided into sections, and each canal, intake, and withdrawal point receives a percentage of the water in that section of the river. Volumetric equivalencies of river shares are stipulated for the flow of the river that occurs in 85 out of 100 years. When river flows are insufficient to meet volumetric specifications,

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[2] D.F.L. Number 1122, published in the Official Journal, Santiago, October 29, 1981.

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[2] D.F.L. Number 1122, published in the Official Journal, Santiago, October 29, 1981.

water flows into the different intakes are reduced proportionally. However, rights on some rivers have been over allocated so that water flows will be sufficient to meet volumetric specifications in far less than 85% of years.

Since consumptive use rights are granted for the full use of all the water stipulated in the right, downstream users do not have any right to return flows generated from upstream users. Of course, this has little effect on the first section of a river since return flows mostly augment downstream sections. Water users in downstream sections of a river divide water that enters through springs, rainfall, and return flows. These rights holders are not protected by law from any change in upstream water use that significantly reduces return flows. There is also no restriction on the transfer of upstream water to another basin.

Water-use rights are required for groundwater exploitation. Individuals can request from the *Dirección General de Aguas* (General Directorate of Water) a right to groundwater, once they have confirmed the existence of a certain yield, at a certain depth. The groundwater-use right is accompanied by a prohibition on other groundwater withdrawals in the protective area specified in the right. Any party with legally entitled rights to water that may be adversely affected by the granting of new groundwater-use rights, can oppose the grant, by informing the regional *Dirección General de Aguas* office within 30 days of the publication of the entitlement in the Official Journal[3]. If a petition is opposed, the Regional Director of the *Dirección General de Aguas* can either grant or permit the new water-use right.

There is no property tax on water-use rights. But land is taxed according to its productive value, which accounts for irrigation. There are seven different categories of agricultural land for tax purposes. These range from high quality, irrigated, central valley land to non-irrigated land. Thus the concept of separating land and water has not reached the tax code. There is no sales tax on the transfer of water-use rights, but there are fees paid to lawyers, notaries, and the Real Estate Registry, *conservador de bienes raices* (CBR).

Water User Associations and Irrigation Development

Historically, the development of irrigation in Chile has been dominated by the private sector. Over one million ha. have been developed for irrigation with private investment (Gazmuri, 1994). These were mostly small run-of-the-river systems. Starting around 1930, the government began developing major irrigation infrastructure. Many of these investments were never completed, and since 1945 only one major irrigation system (the Paloma Reservoir system in the Limarí Valley) was built by the government. Also, long-term contracts to recover costs from users were denominated in local currency which has since lost value drastically. In the 1970s both private and public investment in irrigation was absent due to the uncertainty of agrarian reform and government austerity. With more secure land and water rights, and liberalized agricultural policy, private investment in irrigation for high-valued fruit and vegetable crops rapidly expanded in the 1980s.

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[3] Owners of rights to surface water and water user associations have opposed groundwater exploitation near rivers and canals.

All privately developed irrigation systems and many of those developed by the state are owned and controlled by independent water user associations (WUAs). These WUAs are owned and operated by their members, and charge fees based on the their capital and operating costs. The WUAs maintain the canal systems, keep records of rights holders, apportion water to individual rights holders according to their recorded shares, and enforce water rights. The 1981 Water Code specifies rules for the formation, governance, and obligations of these WUAs.

There are three different types of WUAs that are recognized in Chile. A water community, *communidad de agua*, consists of any water users that share a common source of water. They can be chartered and recognized, with formal procedures, but many *communidades de agua* are not. Irrigation Associations, *asociaciones de canalistas*, serve irrigators that share a common canal, and have a legal status which allows them to enter into contracts and receive financing. *Juntas de vigilancia* (JDVs), made up of all users and user associations on a common stream or section of a river, are responsible for administering water use in the river. JDVs control the canal intakes that flow from the river. Some JDVs administer dams for storage of irrigation water. At the national level the Confederation of Canal Operators (CCC) is legally recognized as the representative of most WUAs. According to the CCC, about one half of all WUAs are legally registered with the *Dirección General de Aguas*.

The Ministry of Public Works (MOP), which includes the *Dirección General de Aguas*, has played an important in water management in Chile. Its *Dirección de Riego* (Directorate of Irrigation) is responsible for planning, supervising construction, and operation of public sector irrigation infrastructure. The National Irrigation Commission (CNR) is an interministerial committee chaired by the Minister of Economy with the membership of the Ministries of Finance, Public Works, Agriculture, and Planning. The CNR is the major government entity which determines irrigation policy. Except for recent initiatives in the construction of several large schemes, there has been no public investment in large irrigation projects for the last 15 years (Gazmuri, 1993).

Water Supply and Sanitation

Chile has traditionally had a high level of water and sewerage coverage: 98% of urban and 75% of rural households have had household access to piped water, and 80% of urban households are connected to central sewerage systems. However, in the past fifteen years the water and sanitation services have undergone a major transformation. In 1990, the regulatory functions of the former national water supply and sanitation service, SENDOS, were transferred to the newly created Superintendency of Sanitary Services (SSS). In addition, SENDOS was decentralized into 11 separate, autonomous, regional water supply and sanitation (WSS) companies, along the lines of the Metropolitan WSS Company of Santiago (EMOS) and the WSS Company of Valparaíso (ESVAL). Stock is currently held by the government and CORFO, a publicly owned corporation.

These independent water companies are obligated by law to provide water and sanitation services to the large municipal areas. They are required to deliver full water supply to their concessions 95% of the time. Water rates are based on delivery costs, with a fair return on capital, and reviewed every five years by SSS. A premium is charged in the summer months in order to manage demand during periods of high use. These water companies have inherited the water-use rights that were traditionally held by the municipalities that they serve and later held by SENDOS. Some of these rights are considered to be priority rights, and consequently, such volumetric withdrawals are not reduced proportionally during times of water scarcity as is the case of other shares. There is a government program, operated through the municipalities, to subsidize potable water supply and sanitation service charges to low-income households.

Environment

The Chilean constitution guarantees citizens the right to live in a pollution free environment. Water quality standards for both agricultural use and potable water have been adopted. But generalized water quality standards that limit the effluent that can be placed in a river or stream have not yet been adopted. The 1993 proposed amendments to the Water Code would have empowered the *Dirección General de Aguas* to set these standards. Currently the *Dirección General de Aguas*'s Environmental Department and the Superintendency of Sanitary Services (SSS) are coordinating to inventory all the polluters in the country[4]. Information on the actual amounts of each contaminant is collected in areas where SSS is monitoring drinking water, but this information is not part of the inventory. Based on this inventory, SSS is developing basic standards to ensure the enforcement of a 1916 law concerning industrial effluents[5].

A major source of water quality problems is the natural sediment flowing from the highly eroded Andes mountain range. This is a young mountain range which has been deforested for centuries, and reforestation efforts are only marginal. Both the mining and industrial sectors are known to produce harmful effluents. Most large mining operations have made efforts to control pollution in order not to disturb the environmental sensibilities of stockholders and the public at large. In southern Chile, a large percentage of water quality problems result from large pulp mills.

In the Santiago area, there is one particular water course — used for irrigation — that has been until recently, an open sewer. Outbreaks of cholera and typhoid have led to a controversy over the reuse of municipal wastewater in the irrigation of food crops. Historically, regulations made by public health authorities on the type of cultivation allowable with wastewater irrigation have been enforced inconsistently. However, new vigilance, including efforts to limit the sale of certain horticultural products — as well as the increased demand for produce that is irrigated with safe water — have decreased the risk of food born diseases considerably.

Formal institutions responsible for environmental management and protection are new to Chile. Two commissions, the Environmental Legislation Committee (COLMA) and the National Ecological Commission (CONADE), were formed in the early 1980s but remained relatively inactive. In 1990, The National Environmental Commission (CONAMA) was formed. The central role of CONAMA in formulating an environmental agenda for the government was reaffirmed by President Aylwin in May 1992. In early 1994, the government passed legislation to require environmental impact studies for new construction and development projects.

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[4] Interview with Carlos Salazar, DGA, June 1993.

[5] Memo from Terence Lee, CEPAL, March 1995.

Regulation and Conflict Resolution

The *Dirección General de Aguas*, which is part of the Ministry of Public Works (MOP) is responsible for water resources planning and the development and exploitation of water resources. It collects data on water resources, maintains cadastres of water use, and has limited authority to intervene in conflicts between water users. The *Dirección General de Aguas* also grants, upon petition, water-use rights for surface and groundwater that is not already claimed. These grants are a matter of public record, and are published in the Official Journal in both Santiago and the regional capitals. During times of drought the *Dirección General de Aguas* can impound water, with compensation to water-use rights holders.

Currently, the *Dirección General de Aguas* is involved in a project to "regularize" water rights. Regularization entails the creation of an inventory of all rights holders, including rights that have not been formally titled. This process includes the specification of water flows and the water-use rights of irrigators holding traditional water-use rights. Regularization does not involve actual titling, which is done at the local real estate registry at the owners expense.

Although the *Dirección General de Aguas* does have broad authority in water resources management, much of the actual control over river flows is exercised by the local river monitoring authorities the *juntas de vigilancia* (JDV). These JDV manage and maintain storage reservoirs, and are responsible for reducing the flow of water to canals during times of water scarcity. These JDV are controlled by the river's water-use rights holders on a particular section of a river. The votes each rights holder possesses depends on the number of shares each owns. Thus in some river basins, irrigators, mining companies, and water supply companies are part of the same JDV. Currently, the court system is the final arbiter of water use conflicts. But the effectiveness of the courts in conflict management has been limited by judicial restraint and an over-emphasis on formalism[6] (Bauer, 1993).

Recent Events in Water Resources Management

The ability of current institutions to effectively resolve conflicts is being challenged, especially in the BíoBío basin in south-central Chile. In this area, irrigation, hydroelectric power generation, industry, municipal water supply, and recreation all compete for use and control of the river waters. Much of the conflict in this area results from the 1981 Water Code's stipulation of non-consumptive rights (Bauer, 1993). Non-consumptive rights were originally designed to encourage the development of hydroelectric generation. The Water Code specifies that these rights shall not interfere with other water-use rights. But it is quite possible that the hydroelectric generation company will schedule water releases from the Pangue Dam on the BíoBío River (under construction) in a manner that would harm downstream irrigators with consumptive use rights.

This dispute was initially resolved by a Court of Appeals of Concepción ruling that protected downstream users from the unwarranted use of non-consumptive rights in the regulation

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[6] This is a general characteristic of the Chilean legal system, which has not demonstrated the institutional capacity to creatively resolve conflicts.

of river flows. However, this ruling was overturned by the Supreme Court which ruled that non-consumptive rights did include a right to regulate stream flows. The Supreme Court ruling does allow for damaged parties to seek ex-post compensation, but does not grant irrigators ex-ante participation in determining the timing of water flows. This ruling was clearly unfavorable to irrigators since it transfers some of their property rights to a large hydroelectric company, and would require them to absorb the high cost of litigation in order to seek compensation for losses.

In 1993 the *Dirección General de Aguas* presented to Congress several amendments to the 1981 Water Code. These modifications would: i) return to the state water-use rights that have been granted by the state but not used for productive ends for a period of five years; ii) strengthen the role of the *Dirección General de Aguas* in monitoring and regulating water quality; iii) establish autonomous river management corporations; and iv) require state approval of new water uses in the extreme northern regions of the country. Although the five year use-it-or-lose-it rule was designed to correct the initial allocation of a large number of rights to ENDESA, Chile's largest electric generation company, most water-use rights holders considered it to be a threat to their right to private property. These modifications have yet to be passed in Congress, and a modified proposal by the *Dirección General de Aguas* is expected.

In recommending river management corporations, the *Dirección General de Aguas* was motivated by the principle of decentralized management. Also, the government hoped that the river basin corporations would accept responsibility for watershed management, coordinate water use, and mediate disputes between users. But there was little mention in the proposed legislation of how these corporations should be constituted and how power would be shared with existing JDVs. This lack of specifics led to some confusion and distrust among irrigators who feared that these new authorities would take away power from the JDVs that have been traditionally controlled by irrigators.

IV. LOCAL WATER MARKETS AND GAINS FROM TRADE

Intersectoral and Intrasectoral Trade in Water-Use Rights

Chile has an environment where water use is limited by both resource scarcity and legally defined property rights and where the value of water in varies between different uses. Thus, trade for water-use rights, both between farmers and urban users and amongst farmers, is expected. Because of the relatively low value of water in traditional agriculture, the seller of water-use rights would most likely be a farmer. A farmer would be better off selling water-use rights if the present value of these rights - calculated as the expected value of the discounted marginal product of water - is less than the price offered by a buyer.

Of course, the farmer may be paid more than this present value. In this case the difference between the present value of the water-use right in agriculture and the price that is determined by the supply and demand of water would be an economic rent that would accrue to the farmer as owner of the property right. Similarly, the difference between the present value of a water-use right to a buyer and the purchase price of the right is an economic rent that accrues to the buyer. The difference between the value of the water-use right to the buyer and its value to the seller is society's gains-from-trade.

A MODEL

These concepts can be formalized using the following equations. Assume, for simplicity, that each farmer plants one crop in a particular location every year. Let farmer *i*, have a profit function:

$$\Pi_t^i(X_t^{i*}(W_t^i,L_t^i,P,R)) = PF(X_t^{i*}(W_t^i,L_t^i,P,R)) - RX_t^{i*} \qquad (1)$$

where:

$\Pi^i_t(.)$	=	farmer i's profit function in year t;
$F(.)$	=	a well-behaved, increasing, concave, continuously differentiable production function;
X^{i*}_t	=	a vector representing the profit maximizing allocation of inputs;
W^i_t	=	pre-determined quantity of water-use rights available to farmer i in year t;
L^i_t	=	pre-determined quantity of land available to farmer i in year t;
R	=	a vector of exogenously determined input prices; and
P	=	the exogenously determined output price, and $t = (1,2,3\ldots)$.

Since the production function is well behaved, the profit function can be denoted in its reduced form $\Pi^i_t(W^i_t,L^i_t,R,P)$. Thus, the value to a farmer of an endowment of land and water-use rights $V^i_t(W^i_t,L^i_t)$ is the present value of a discounted stream of profits that can be earned with the use of the land and water, as shown:

$$V_t^i(W_t^i,L_t^i) = \sum_t \frac{(\Pi_t^i(W_t^i,L_t^i,R,P))}{(1+r)^t}, \qquad t = (1,2,3,\ldots). \qquad (2)$$

And after accounting for the value of land, the value of water $V^i_t(W^i_t)$ can be derived. Of course, if a farmer does not have positive profits, then the value of water will be negative.

The demand for water in urban areas is the sum of: 1) household demand for water in residential use; 2) industrial demand, based on the value of the marginal product of water in industry; and 3) public demand for water for recreational, amenity, environmental, and public health uses. All individuals and firms in an urban area would solve different constrained maximization problems and develop input demands for water use that are dependent on prices, incomes, and production technology. Thus, an urban water company's (UWC) demand for water is a derived demand, in which population and income are key parameters. In Chile, UWCs are profit maximizing firms, but are regulated and required by law to meet this urban demand for water, D_t^*. Because rates are determined administratively, these companies will have incentives to minimize the discounted costs,

$$COST = \sum_t \frac{P_t^X X_t + P_t^W w_t}{(1+r)^t} \tag{3}$$

subject to

$$D_t^* \leq Y(W_t^U, X_t) \tag{4}$$

and

$$W_t^U = w_t + W_{t-1}^U \tag{5}$$

where:

W^U_t	=	the UWC's stock of available water rights in year t,
X_t	=	a vector of non-water inputs into the UWC's production function,
w_t	=	water rights purchased or obtained through alternative means by the UWC in year t,
D_t^*	=	the amount of water that the UWC is required to supply to its customers in year t,
P_t^X	=	a vector of input prices,
P_t^W	=	the least cost input price of water rights that are either purchased or obtained through alternative means,
$Y(W^U_t, X_t)$	=	the UWC's well-behaved, increasing, concave, continuously differentiable production function for water supply, and t = (1,2,3,...).

If the constraints are binding, than an UWC's indirect demand for water-use rights in year t can be defined as $w_t^*(P_t^W, P_t^X, W^U_{t-1}, D_t^*)$. Given an alternative cost of acquiring these rights, $P_t^{W(A)}$, the UWC's maximum willingness-to-pay for water-use rights, $V^U(w^*_t)$ can be determined as shown:

$$V_t^U(w_t^*) = P_t^{W(A)} w_t^*(P_t^X, P_t^W, W_{t-1}^U, D_t^*). \tag{6}$$

For simplicity, assume that an urban water company is buying water-use rights w from farmer i. The net gains-from-trade to society from this transaction is the difference between the value of the water to the buyer and seller less the transactions costs, as shown:

$$GFT_t^{U,i}(w) = [V_t^U(w) - V_t^i(w(W_{t-1}^i - w))] - TC^{U,i}(w) \tag{7}$$

where: $GFT^{U,i}(w)$ = the gains-from-trade to society of a transfer of w from farmer i to the urban water supply company,

$TC^{U,i}(w)$ = the total transactions costs of a transfer of w from farmer i to the urban water supply company, and

$V_t^i(w(W_{t-1}^i - w)$ = the value of water-use rights w, as a percentage of the average value of total post-trade water-use rights $(W_{t-1}^i - w)$.

The net rents to farmer i of the trade can be calculated as shown:

$$NR_t^i(w) = P_t^{W(U,i)}w - [V^i(w(W_{t-1}^i - w)) + TC^i(w)] \tag{8}$$

where: $P_t^{W(U,i)}$ = the transfer price of w negotiated between farmer i and the urban water supply company,

$NR_t^i(w)$ = the net rent to farmer i of a sale of w to the urban water supply company, and

$TC^i(w)$ = farmer i's transactions costs.

Similarly, the net rents to the buyer can be calculated as shown:

$$NR_t^U(w) = V_t^U(w) - [P_t^{W(U,i)}w + TC^U(w)]. \tag{9}$$

CALCULATION OF GAINS-FROM-TRADE AND ECONOMIC RENTS

In order to assess the impact of water markets and transaction costs in Chile, four river valleys, the upper Maipo in Chile's central valley, and the Elqui and Limarí in north-central Chile, and the Azapa in the far north of Chile were selected as case studies (see ANNEX I and Maps Section). These valleys were identified based on prior information which suggested that there was — or should be — active trading in the area. Attempts were made to identify all transactions of water-use rights in these areas for the years 86-93. These years were chosen because of reports of more active trading in recent years, because they include both wet and dry years, and because farmers were expected to provide more accurate information on recent transactions. Water transactions in conjunction with land transactions were generally not considered, because they usually do not represent a change in water use patterns.

A survey instrument was developed to solicit information from farmers who have participated in water market transactions (see ANNEX III). This information included: i) individual characteristics of buyers and sellers; ii) water transactions, including price, quantity, and transaction costs; iii) farmer's investments in irrigation technology, groundwater, small dams, and canal operation and maintenance; and iv) farmer's crop yields. The survey instrument was pretested with farmers in the Maipo Valley who had not participated in market transactions.

Individuals making transactions were identified from records of WUAs, from local *Conservadores de Bienes Raices*, and from other transacting parties. Agronomists from the *Universidad Católica* of Santiago were recruited as enumerators. Enumerators attempted to contact all individuals who had made transactions in the areas selected for analysis. Managers of urban water supply companies and industrial users of water were also interviewed.

Crop Budget Analysis in Valuing Water Rights

The net returns calculated using farm budget analyses is an upper bound to farmer's willingness to pay for water in irrigation. This is not a marginal analysis, but an estimate of the average value of water. The net returns to a farmer is the maximum that a farmer could pay for water and land, and still break even. In this study, farm budgets are used for both an economic and financial analysis of water markets[7]. Net returns are divided between land and water according to relative market values (solicited in this study using a survey of farmers, see ANNEX III) of land and water used in crop production. A summary of all the assumptions used in the gains-from-trade analysis is presented, along with summary data in Table 1. An example of a representative crop budget is shown in Table 2. Other crop budgets used are presented in ANNEX II. The following paragraphs explain this procedure and the assumptions used.

Yields and Production Costs

Farmer's per hectare yields are based on survey data. In the case where farmers did not respond to this question, average yields from other surveyed farmers were used. Output price and cost of production information were taken from representative crop budgets used by the *Dirección de Riego* and the Department of Economics of The *Universidad Católica* of Chile in the financial and economic appraisal of irrigation projects in the Elqui and Limarí valleys, dated 1991 and 1992[8]. In situations where either representative crop budgets or yield data were not available for a particular crop grown by an individual farmer, the average value of water for the farmer's other crops was substituted.

[7] The financial analysis is performed to determine individual incentives to participate in water markets. In contrast, the economic analysis provides the net return to society of market transfers. In an economic analysis, transfer payments are excluded and prices are adjusted for economic values (explained in more detail later in this chapter).

[8] Crop budget data was dated 1990 and 1991.

Table 1: Assumptions Used in Gains-From-Trade Calculation

CROP BUDGETS

	PARAMETER	ASSUMPTION
1.	**Input Prices**	Taken from representative crop budgets used in evaluation of irrigation projects in Region IV.

INPUT	UNIT	PRICE 1991 CH $[a]
Labor	Daily Rate	1,500
Urea	Kg	101
Fosfato Diamonico	Kg	107
Sulfato Potasio	Kg	116
Citrolliv	Liter	513
Parathioin	Liter	3,000

2. **Output Prices** — Taken from representative crop budgets used in evaluation of irrigation projects in Region IV.

OUTPUT	UNIT	PRICE 1991 CH $[b]
Table Grapes	Kg	218
Pisco Grapes	Kg	80
Tomatoes	Kg	52
Chile Pepper	Kg	500
Wheat	Kg	79
Corn	Kg	500

3. **Yields** (Kilograms/Ha) — Taken from survey data.

CROP	N[c]	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
Table Grapes	27	14,900	8,000	22,500	4,445
Pisco Grapes	25	31,484	3,640	80,000	14,251
Field Tomatoes	15	17,230	5,850	30,000	6,999
Greenhouse Tomatoes	6	57,570	37,800	97,200	8,856
Chile Pepper	4	1,600	900	3,500	1,270
Wheat	6	2,380	1,500	3,200	830
Corn	5	2,700	1,700	5,000	1,200

[a] Prices are later inflated to account for 1993 prices.
[b] Prices are later inflated to account for 1993 prices.
[c] Many farmers could not give yield estimates.

Table 1: Continued

4. **Costs of Water Delivery** Taken from survey data.[d]

Elqui Valley Total Cost of Water Delivery 1993 $ Ch per Share/Year

N	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
28	14,464	0.00[e]	124,000	24,066

Limarí Valley Total Cost of Water Delivery 1993 $ Ch per M^3/Year

N	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
65	3.77	0.00	18.37	3.09

5. **Management Premium** 7%.

6. **Commercial Loan Rate** 15%.

7. **Interseasonal Finance** 50% of input costs for 6 month.

8. **Discount Rate** 12%.

9. **Grape Production** Full production after 6 years, which continues for 25 years, no production after the 25 years.

10. **Crop Development Loan** 3 year disbursement, 3 year grace, and 19 year payment.

11. **Net Returns to Land and Water** Calculation based on survey responses and farmers' perceived value of land and water-use rights.

[d] Farmer's annual payments to water user associations and for additional costs for cleaning canals that are outside a farm gate.

[e] Some individuals had purchased rights, but not yet transferred water.

Table 1: Continued

12. **Ratios of Value of Water to Values of Water and Land**

	N[f]	MEAN	MINIMUM	MAXIMUM	STANDARD DEVIATION
Elqui Valley	20	0.43	0.02	0.88	0.28
Limarí Valley	120	0.55	0.05	0.93	0.24

13. **Term** 50 years.

14. **Farm Sizes** Taken from survey data.

15. **Hectares in Production**

	N	MEAN	MINIMUM[g]	MAXIMUM	STANDARD DEVIATION
Elqui Valley	29	17	0	172	36
Limarí Valley	69	53	0	1,200	167

16. **Number of Interviews**

	BUYERS	SELLERS
Elqui Valley	18	14
Limarí Valley	19	37

POTABLE WATER

17. Growth Rate of Water Demand in Coquimbo/La Serena Area — 2.1%

18. Cost of Alternative Water Source in Elqui Valley — US $23,500,000 (1992)

19. Value of Elqui River Water for Potable Water Supply — see Table 4.

[f] Ratio of the value of water to the value of water and land for each crop for each farmer.

[g] Both individuals that had left farming and individuals that had purchased water for small country houses had zero hectares in production.

Table 2: Representative Crop Budget (Table Grapes)

Field Type[a]	- 50 Ha. Table Grapes, Drip Irrigation - Monte Patria, Limarí, IV Region, Chile - with 100 Shares of Water from Cogotí Reservoir		
			Thousand $ Ch[b]
Total Revenue	16,400 kg/ha * 218 $/kg * 50 ha		178,760
Cost[c]	Machinery	48,000 $/ha	
	Labor 126.5 days * 1,500 $/day	189,750 $/ha	
	Inputs	985,961 $/ha	
	Total 50 ha *	1,223,711 $/ha	(61,186)
	Cost of Water Delivery[d]		(837)
	Intraseasonal Finance 50% of costs * 6 months @ 15%		(2,335)
Net Revenue			114,402
minus 7% management		(7,991)	106,411
minus land tax 10% of 50% stated value[e]		(2,500)	103,911
minus debt service for crop development and drip irrigation installation 3 year disbursement, 3 year grace, 19 year payment @ 15%		(60,559)	43,352
Net Returns to Land and Water			43,352
minus 29% relative value of land		(12,572)	30,800
Net Return per Water Right			308
Present Value of Water Rights @ 12% interest, 50 year term			2,558

[a] Farm, yield, water, and land information taken from survey data. More than one crop may be grown on these farms.

[b] The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[c] Input and output prices are taken from representative crop budgets used in Dirección de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values.

[d] Survey data on fees paid to WUAs for water delivery and labor assigned to clean exterior canals. Figures reported in 1993 terms were initially deflated to correspond to the rest of the cost information.

[e] Land taxes are included in the financial analyses and not in the economic analyses.

Output and Input Prices

Because a time series of input prices was not available, relative input and output prices are assumed to remain constant. Output prices for export fruit crops, especially table grapes, can be highly volatile. Because the export price of table grapes is volatile, and has decreased since the dates of the representative crop budgets, the analyses for the Limarí Valley was also performed with an alternative price for export grapes of 25% below the reported crop budget price. Most table grape production is assumed to be sold on the high-priced international market, but 25 percent of total output is sold on the national market at a lesser price. Output prices for pisco grapes are determined by the two local pisco production cooperatives and are fairly stable.

Cost of Water Delivery

Farmer's cost in supplying labor to clean common canals and water fees paid to WUAs are included as production costs, because they account solely for the cost of water delivery. WUAs are non-profit organizations, and they determine their own fees in accordance with their capital and operating costs. Some farmers in the Limarí Valley receive water delivery services from the government-owned Paloma Reservoir, but they do not pay for this service. The cost of labor to clean canals within the farm are included in the labor cost of the crop budget. Farmers' total expenditure for water is multiplied by the percentage of water used for each crop as determined in the interview.

Debt Service

The cost of servicing a debt to cover the costs of initial crop development is included for all permanent crops. These costs are taken from the same crop budget information. For grape vines, partial yields are present in the third year, but at 16% of production this is not sufficient to cover operating costs. Thus the crop budget is representative of a year of full production, with debt service for the first three years of negative net returns, with three more years of grace to allow for full production before debt servicing. The fruitful life span of a grape vine is assumed to be 25 years, after which, yields decline dramatically.

Management and Risk

Net revenues are discounted by 7 percent in order to account for management services. Seven percent is considered a standard charge for management [9]. In order to account for the risk absorbed by a farmer, loan rates used for both interseasonal finance and crop development were set at the 15% commercial rate, which would include a risk premium.

Land Taxes

In Chile agricultural taxes are fairly complex. A simple option for farmers is to pay a land tax of 10% of an assessed value. The stated assessed value is probably much less than the market value reported in the survey, and for this reason reported market values are discounted by 50%. Land taxes payments were deducted from net revenues in the financial analysis of rents to buyers and sellers. These payments were not deducted from net revenues in the economic analysis because they are transfer payments that do not reflect a net loss to society.

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[9] Alkire (1990) uses this number as a standard, Young and Gray (1972) suggest 6 - 10 % (page 112).

Net Returns to Land

The returns to land are derived in order to determine the residual value that can be attributed to water. One method of determining the value of land that is independent of the value of water is to use the value of dryland. Computationally this methodology would be attractive because dryland in this area is used only in very low-intensive goat herding and has a value that approaches zero. However, this methodology would fail to incorporate the locational attributes of land that is adjacent to canals or rivers. This land is valuable because it can be irrigated without the cost of constructing canals, because it often can be irrigated without permanent water-use rights during times of high-water, and because irrigated land also has greater accessibility to roads and other infrastructure. Thus, in this study the value of land was determined by the relative value of land and water as revealed in the survey of farmers in which they were asked to estimate the value of their land without water-use rights as well as the value of their water.

Value of Water for Potable Water Supply in the Elqui Valley

The value of water-use rights of the Elqui River to ESSCO can be determined from ESSCO's ability to use these rights to forego the need to invest in more costly alternatives to obtain water supplies. Since the demand for water in this service area will continue to rise, the least cost alternative for meeting this demand — in the absence of effective water markets — is the appropriate methodology for assessing the value of water. Groundwater in this area is very deep, and of poor quality, and would not be a cost-effective alternative, except for emergency supplies in summer months.

Another alternative would be to construct a water storage project in the Elqui River. In fact, ESSCO has opted out of a proposed joint venture with *Dirección de Riego* to construct the Puclaro Dam on the Río Elqui. At a cost of US $23,500,000, ESSCO was offered sufficient capacity in the proposed reservoir to meet its needs for secure water supplies well into the next century[10]. If this dam were in place, ESSCO could fill its part of the reservoir during times of high water flows. ESSCO's refusal of this offer coincided with its current program to purchase water-use rights on the Elqui River.

Many of the water-use rights transactions in the Elqui valley involved the transfer of water from agriculture to potable water uses for residences outside of ESSCO's command area. A few of these transfers involved purchases of a small quantity of water by small investors interested in developing plots of land along the river — and adjacent highway — for country homes and small tourist cabins. Other transactions involved the same type of investment but in the upper reaches of the Elqui valley. Another purchaser was interested in developing a large tourist and residential area on the beach north of the city of La Serena. Since this area is outside ESSCO's service area, and an agreement to purchase crude water from ESSCO was not guaranteed, this developer began to purchase water-use rights on the Elqui River.

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[10] Conversation with *Dirección de Riego*, Santiago, June 1992. The *Dirección de Riego* also offered reservoir water at a lower price but without the security of delivery that ESSCO is required to have.

In placing a value on water-use rights for these developers it is important to note their possible alternative water sources. Groundwater pumping along the Elqui River is opposed by the *Junta de Vigilancia* which represents water users. Outside of the immediate valley, groundwater is both expensive to exploit and of poor quality for potable water. Thus, the most likely alternative source of crude water supplies for all of these tourist developments is the same source as ESSCO's. Therefore, the cost of water to ESSCO is also the value of a water-use right to others needing potable water supplies downstream of the proposed Puclaro Dam project. Two necessary assumptions will be made in using this procedure. First it is assumed that these smaller entities can receive crude water at ESSCO's cost, and no additional transactions costs are involved. Another assumption is that this additional water demand does not affect the timetable of water demand and value as shown in Table 3. Consequently, these estimates may undervalue water for smaller developers who may actually have to purchase more expensive water.

Table 3: Value of Water Rights for ESSCO's Purchases

Year of Purchase	Year of Demand	Number of Shares	Value of a Share
1992[a]	2010[b]	45.3	$ 2,561,220
1992	2011	21.9	$ 2,204,690
1993	2011	25.0	$ 2,475,505
1993	2012	47.7	$ 2,157,305
1993	2013	48.5	$ 1,881,798
1993	2014	36.6	$ 1,643,589

[a] ESSCO purchased 67.2 shares in 1992 and 157.8 shares in 1993.
[b] Projected demand based on current growth in water use.

Following a procedure similar to that outlined in Moncur and Pollack (1988), the value of water-use rights is estimated as the cost avoided by not investing in the Puclaro Dam (see Figures 6.1). In year T, ESSCO's current supply of water, provided at a cost of C_1, will be insufficient to meet a growing demand for water. At that time a new water supply, at a cost of C_2, must be made available. If, however, the need for this new costly water supply can be postponed, this postponement has a value, Φ_t, which is equal to the total value of all crude water supplies needed to effect the postponement.

Information for the calculation of Φ_t is taken from a 1991 CIAPEP feasibility study of the Puclaro project and from conversations with ESSCO's planning department. To service its demand, ESSCO had in 1991 a total supply of 27.36 million m^3 per year, which includes a few wells and drains, as well as 550 shares of the Elqui River, with each share representing 1 liter/second[11]. This CIAPEP calculation appears to presuppose that the yearly demand for water occurs at the same time as the yearly supply of water, and that this supply is secure in dry years. This is somewhat of a weak assumption given the very large summer population of this beach resort area and the variable flows in the Elqui river. But, river flows during the January-February tourist season are relatively high, and ESSCO enjoys a priority in the delivery of water during dry years, especially for its long-held traditional rights. Furthermore, ESSCO is currently investing in groundwater, largely for the purpose of ensuring emergency water supplies during peak summer periods.

According to the CIAPEP study, the demand for water in the La Serena/Coquimbo service area is growing at a rate of 2.1 percent per annum. At this rate ESSCO's current supply of water will be insufficient to meet its needs by the year 2011 (which also is a reasonable date to have expected — in 1992 — the full completion of the Puclaro Dam project[12]). The value of a water-use right is equal to the costs saved in delaying the need for introducing a more expensive water supply. This value, Φ_t, is the 1992 value of the 570,000 m^3 of water needed in 2010 to cover the increased demand for water. As shown,

$$\Phi_t = \frac{C_2 - C_1}{e^{r(T-t)}} \tag{10}$$

where:	r	=	.12;
	T	=	2010;
	t	=	1992; and
C_2 - C_1 = CH $1,006,054,000		=	the yearly payment for a loan of US $23,500,000, at 12% interest for 35 years, at a 1992 exchange rate of CH $350 = US $1.00.

Thus, Φ_t = CH $116,023,303 which is the 1992 value of the water needed to fulfill ESSCO's unmet water demand in 2010. One interesting feature of this calculation is that the volume of water needed in 2011 is not a factor in the determination of its value. This is because the Puclaro reservoir would be large enough to meet any reasonable increase in demand.

Once the value of the quantity of water needed to delay the investment in the more expensive technology is determined, it is necessary to put this value into a per-share basis. If each right of Elqui River water continues to guarantee 1 liter/second of water, then this amount, Φ_t, is divided by the 18.11 shares that would be required to meet the 2010 demand. However, although

[11] It has been the policy of the Junta de Vigilancia of the Río Elqui (JDVRE) to supply ESSCO with 1 liter/second of water per share, even when the water delivered to other shareholders is reduced because of low river flows.

[12] Fifteen years was needed for full completion of the Paloma Dam project.

Figure 1: Calculation of Avoided Cost of Alternative Supply of Water[a/]

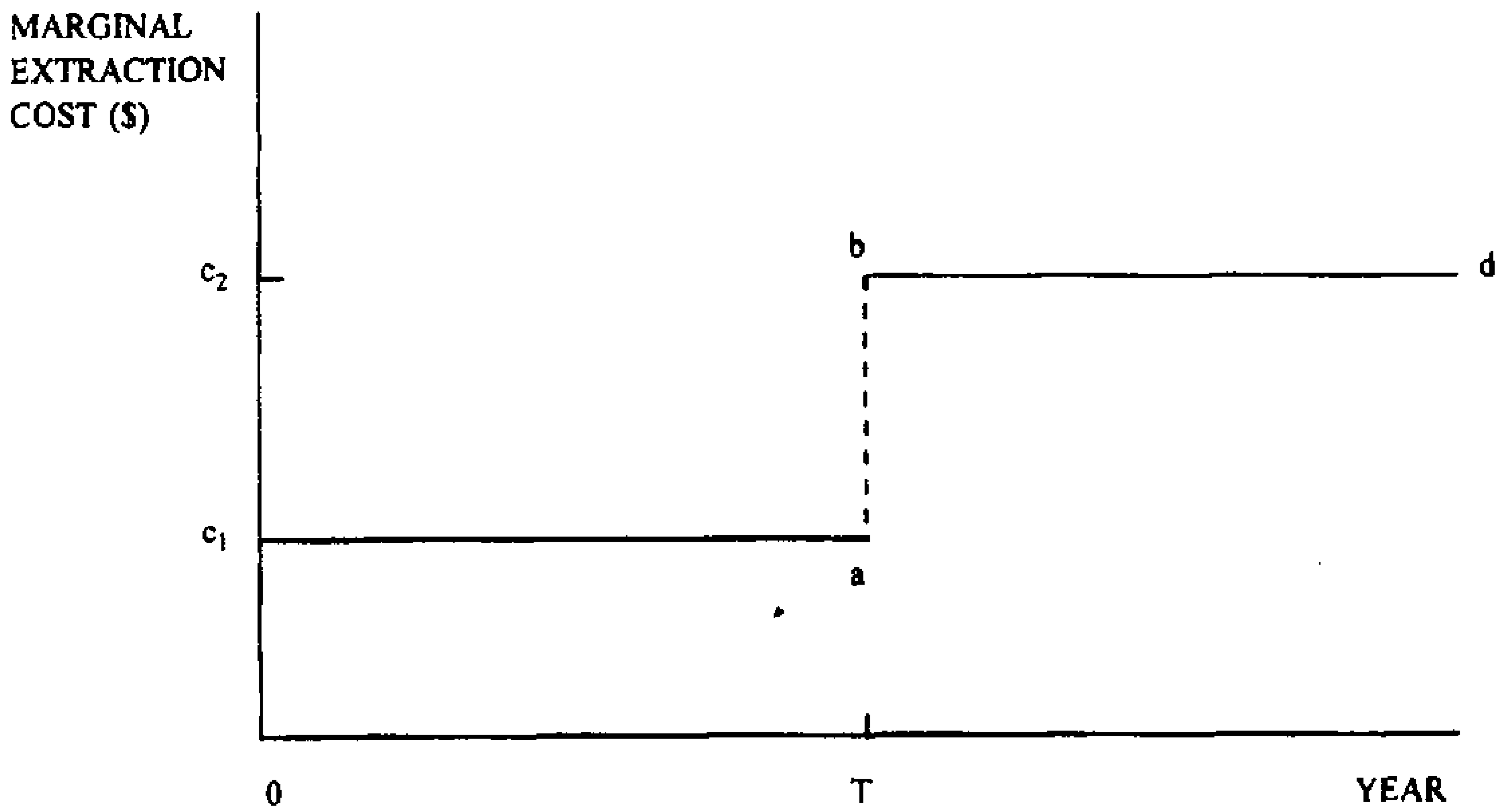

FIGURE 1-1
EXTRACTION COST PATH

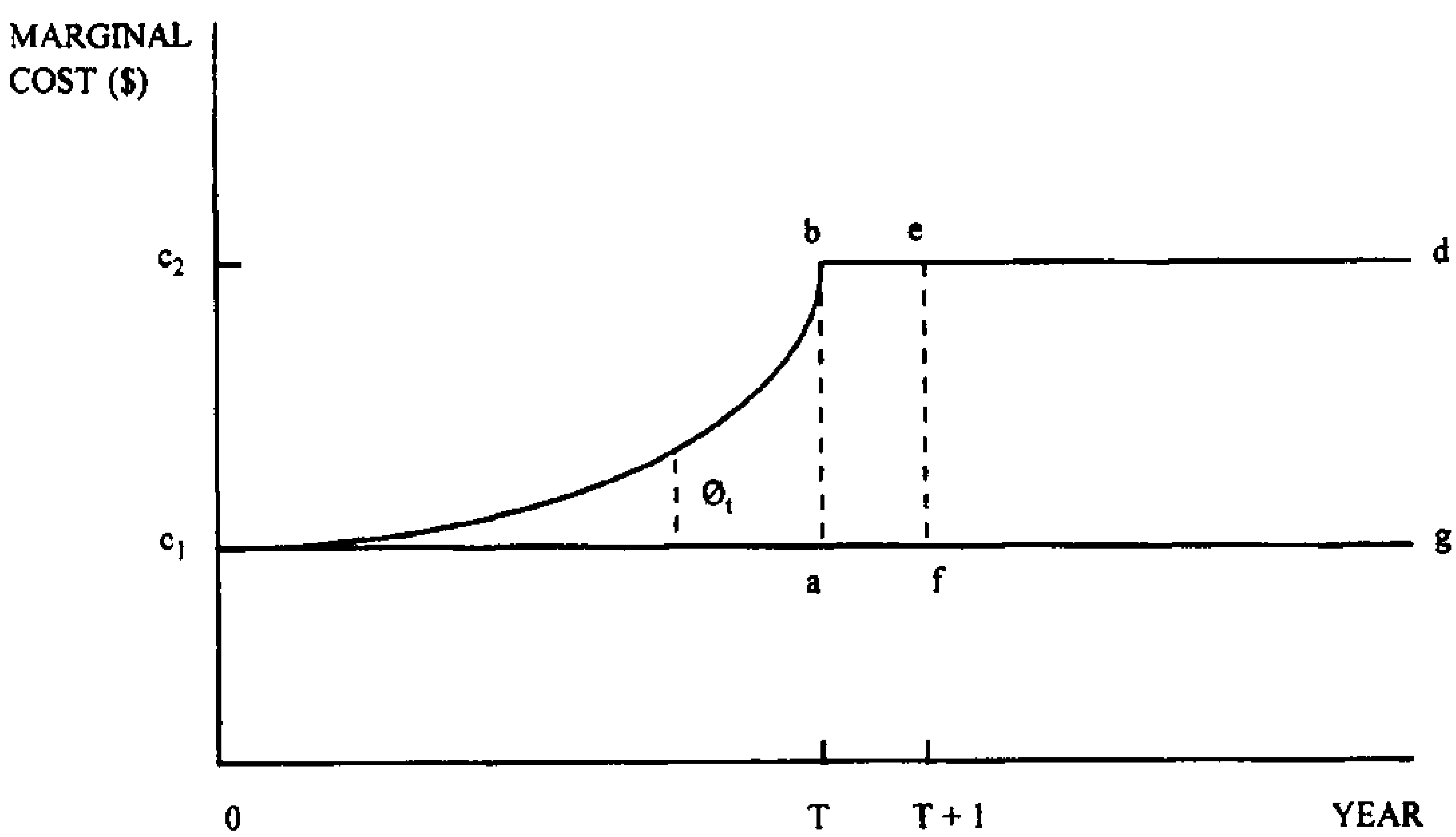

FIGURE 1-2
EFFICIENCY PRICE PATH
CONSTANT MC

[a/] Source: Moncur and Pollack, 1988.

ESSCO's traditional shares carry a priority in water delivery, this priority cannot be guaranteed for future shares. For this reason, it is assumed that 2.5 shares of the Elqui River are needed to ensure each liter/second, because in 95 of 100 months, the lower Elqui River delivers at least 0.4 liters/second per water-use right[13]. Thus, Φ_t = CH $116,023,303 is divided by 45.3 shares to reach a value of CH $2,561,220 for each of the first 45.3 shares purchased in 1992. The value of all 217.8 net shares of Elqui water purchased by ESSCO in 1992-3 are listed in Table 3.

Economic Analysis of Gains-From-Trade

Financial prices taken from representative crop budgets were adjusted to present economic values. Information from the 1991 InterAmerican Course in Preparation and Evaluation of Projects (CIAPEP) study of the Puclaro Dam was used in this adjustment because it contains both economic and financial prices. Because Chile has a relatively open economy with low tariffs, free exchange rates, and open markets, the difference between economic and financial prices are small. For exportable goods, such as table grapes, a percentage of the exporters commission is added to the farmgate price in order to account for this transfer payment. For imported inputs, financial prices are adjusted for both import tariffs (11%) and the foreign exchange premium (10%). Adjustment factors for financial prices to reflect economic values are shown below in Table 4.

Table 4: Adjustment Factors for Economic Prices

Crop and Price	Adjustment Factor
Table Grapes, Output Price	1.084
Table Grapes, Production Costs	0.995
Pisco Grapes, Production Costs	0.997
Corn, Production Costs	1.062
Potato, Production Costs	1.020
Wheat, Production Costs	1.050
Tomato, Production Costs	1.012
Alfalfa, Production Costs	N/A
Chile Pepper, Production Costs	N/A

[13] Municipal water supply companies are, by law, required to have 95% security in water delivery. The estimate of 2.5 shares per liter /second, is taken from a review of the JDVRE's records of water flow in the river, this also corresponds with ESSCO's stated plan to purchase 1300 additional shares of the Elqui River by 2020.

In both the economic and financial analyses, the avoided cost of investing in the Puclaro Reservoir is used to value water for urban water supply in the Elqui Valley. An adjustment was not made to differentiate between the economic and financial costs of constructing the Puclaro Reservoir. The CIAPEP study does provide a discount factor of .991 for social prices to account for the tariffs paid for imported goods. But this report does not detail the percentage of the construction costs which will be dedicated to imported goods. Because the discount factor is so close to 1.00, and the percentage of imported goods is assumed to be relatively small, the financial and economic costs are assumed to be equal.

Gross gains-from-trade were calculated by subtracting the value of water to the seller before a sale from that of the buyer after a purchase. Efforts were made to identify and interview both buyer and seller of each transaction. When only one party of a transaction was interviewed, the value of water from buyers or sellers on the same canal or area for the same year was used to substitute for the other party.

In cases where the seller of a water-use right was known not to have used the water prior to the transaction, the right was valued at the weighted average value-of-water to neighboring farmers. This is because unused water is generally distributed to other water users, along the same canal or river. Because of the interconnections in the Limarí Valley, average values of water for above and below the Paloma Reservoir were used. In the Elqui Valley water was divided between users of the Río Claro and Río Cochiguaz, users of the Río Elqui, and users of the Canal Herradura. In the Limarí Valley, cubic meters of water sold on the spot market, were valued at the weighted average value-of-water to neighboring farmers.

All values were adjusted to June 1993 values using Chile's consumer price index. Transaction costs were obtained in the survey. These costs include: fees for attorneys, notaries, and engineers; payments for modifications of canals or gates; the costs of soliciting information; and the value of the time involved in the process. A summary of total transactions costs for the Elqui and Limarí Valleys is presented in Table 5. Net gains-from-trade were calculated by subtracting the transaction costs to both buyers and sellers from gross gains-from-trade.

Financial Analysis of Economic Rents to Buyers and Sellers

Financial prices were employed in the crop budgets used in the analysis of individual economic rents to buyers and sellers. In this analysis, a water-use right that was not used by the seller prior to the transaction was valued at zero. The seller's net rent is the sale price, adjusted to 1993 values using Chile's consumer price index[14], less the value of the water to the seller and less the seller's transactions cost. To the buyer, the net rent is the difference between the value of water to the buyer and the sum of the buyer's purchase price and transactions cost. As reported, the sum of rents to buyers and sellers does not equal the calculated gains-from-trade.

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[14]Prices for each year were multiplied by the following factors: 1986, 3.19; 1987, 2.68; 1988,2.34; 1989, 2.00; 1990, 1.60; 1991, 1.29; 1992, 1.03.

Table 5: Transactions Costs

	Buyers Elqui Valley	Sellers Elqui Valley	Buyers Limarí Valley	Sellers Limarí Valley
Total Transactions Costs as a Percentage of Transaction Price	0.21	0.02	0.05	0.02
Costs of Attorney's, Notaries, and Obtaining Legal Inscription of Rights as Percentage of Total Transactions Costs	0.59	0.79	0.16	0.34
Costs of Engineering and Modifying Canal Infrastructure as a Percentage of Total Transactions Costs[a]	0.20	0.03	0.64	0.62
Opportunity Cost of Time Invested as a Percentage of Total Transactions Costs	0.20	0.18	0.18	0.00
Costs of Gathering Information on Buyers and Sellers as a Percentage of Total Transactions Costs	0.00	0.00	0.02	0.04

[a] Estimated expenditures for engineering services, modification of gates and canals, and indemnities for transferring water through canals. Includes expenditures through 1993 and does not include planned expenditures for modifications needed in the future.

This is because economic gains differ from financial rents. Also, for some transactions both buyer and seller were not interviewed, and financial rents are calculated and reported only for interviewed parties.

RESULTS

Only the transactions from the Elqui and Limarí valleys were analyzed to determine the gains-from-trade from market transfers. In the upper Maipo valley transactions were rare -- except for water-use rights ceded to municipal water companies from developers of urbanized land -- and were not included in the analysis. Similarly, in the Azapa valley only a few transactions were identified and gains-from-trade were not calculated. In the Elqui valley transactions are infrequent, but there is significant intersectoral transfer as well as a slow transfer of water-use rights within agriculture. In the Limarí Valley, with its well developed system of irrigation infrastructure and well organized WUAs, transactions are fairly frequent.

Net Returns per Share

As a bases for comparison to demonstrate the difference in the value of water in producing alternative crops, average net returns per share were calculated by crop combining data from the

Elqui and Limarí Valleys. The average value-of-water in alternative crop production is shown in Table 6[15]. For the purposes of calculating average values for this table, water-use rights or shares are standardized across valleys, although as discussed below this is not done in the gains-from-trade analyses. As shown, water used in the production of pisco grapes is very valuable. This may be because pisco production is limited by the major pisco distilling cooperatives, and the value of these purchasing agreements is not included in the analysis. There is a lot of variation in these calculated values, especially for table grape and tomato production. Most of this variability is due to the variability in reported yield estimates. Except for pisco grapes and paprika, the average estimated present value of a share of water in crop production is well below reported market prices for the water-use rights.

The Elqui Valley

The Elqui Valley in Chile's Region IV supplies water for 18,700 ha of farmland as well as potable water for a medium-sized city (250,000 inhabitants) with a very large summer population (see ANNEX I and Map 2 in the Maps Section). A small tourist industry in several small communities in the scenic valley compliments the large coastal tourism boom. Major crops include table grapes, pisco grapes, other fruit crops, potatoes, and pasture. One small mine in the upper reaches of the basin utilizes water from a tributary. Rainfall is scarce in this region with average yearly precipitation less than 120 mm. Wet and dry years follow a cyclical pattern, with two and three year droughts common.

In the Elqui Valley a limited population of 47 permanent transactions for the period of 1986-1993 were identified with the assistance of the JDV and other WUAs in the Elqui Valley. For 41 of these transactions representing a total of 712 shares of the river[16,17], either the buyer or seller or both was interviewed. In total, 14 individuals selling 491 shares and 18 buyers purchasing 467 shares were interviewed[18].

[15] For farmers who sold water, total net revenue was divided by the amount of water owned before the transaction. For farmers who bought water, total net revenue was divided by the amount of water owned after the transaction. Net returns are adjusted from the year of the crop budget to 1993 by using Chile's consumer price index. In tabulating averages, all individual farm observations are weighted equally, and not weighted by farm size nor by water use.

[16] There are 25,000 total shares in the Río Elqui each share is supposed to deliver 1 liter/second in a good year, although 0.5 liters/second is generally considered closer to average.

[17] Shares of the Estero Derecho of the Río Claro, which is not controlled by the JDVRE were considered equivalent to shares of the rest of the river, as suggested by local irrigators.

[18] Some individuals were involved in more than one transaction.

Table 6: 1993 Value of Water-Use Right Shares in Crop Production, Chile's IV Region[a]

Crop	Number of Farms	Mean Annual Value of Water Right 1993 $ Ch	Standard Deviation	Mean Present Value of Water Right 1993 $ Ch
Table Grapes constant price	32	$ 189,259	291,738	$ 1,571,700
Table Grapes 25% reduction in international price	32	3,920	19,501	32,555
Pisco Grapes	31	348,894	248,710	2,897,393
Tomatoes	25	16,304	198,622	135,397
Alfalfa	24	33,014	31,174	274,168
Wheat	9	50,467	42,915	419,109
Maize	5	- 45,964	22,906	- 318,713
Chile Pepper	5	127,934	70,307	1,062,432
Potatoes	5	133,583	65,430	1,109,345
Others Paprika, Morron	6	231,050	181,338	1,918,753

[a] Values are in 1993 Chilean pesos. Water-use rights in both the Elqui and the Limarí are included.

Ninety percent of the shares sold in this valley have not been used by their sellers in recent years. Some of these sellers had surplus water, others had rights to water along canals that did not conduct water efficiently, others had quit farming, and still other sellers owned rights to water but did not own land[19].

Purchase prices of shares of the Río Elqui are quite variable, reflecting differences in transaction costs and in many cases the particular conditions of buyers and sellers. ESSCO's average purchase price in 1992-93 was near US $1,100 per share. During the same period, small plot developers in the lower Elqui Valley were paying US $2,500 per share for water in a conveniently located canal. Exchange prices between individual irrigators ranged from US $250 to US $1,000. Often this disparity in prices reflects the individual circumstance of the seller.

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[19] In general water that is not used by its owner is used by neighboring farmers in the same canal or section of the river.

Transaction costs for most transfers are low because this is a narrow valley with many short canals flowing directly from the Río Elqui and its tributaries (see Table 5).

Results of the economic analysis of gains-from-trade in the Elqui Valley are shown in Table 7. The average gross gains from trade for the 712 shares were US $846[20] per share. With an average transaction cost of US $56 per share, net gains-from-trade are US $790 per share.

Table 7: Economic Analysis of Gains-from-Trade: Elqui Valley

Elqui Valley	Number of Shares	U.S. $ per share[a]
Total Gains-From-Trade	712	846
Net Gains-From-Trade	712	790
Trades with ESSCO Total Gains-From-Trade	298	675
Trades with ESSCO Net Gains-From-Trade	298	658
Other Intersectoral Trades Total Gains-From-Trade	63	1160
Other Intersectoral Trades Net Gains-From-Trade	63	1139
Intra-Agricultural Trades Total Gains-From-Trade	351	934
Intra-Agricultural Trades Net Gains-From-Trade	351	839

[a] The June 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.

ESSCO has purchased 292 shares of the river, which amounts to 28% of its current water-use rights. The estimated net economic gains from these transfers (US $658 per share) are relatively modest. One reason for this is that much of the water sold to ESSCO was not used by their previous owners, and the procedure of using the value of water to neighboring farmers may be biased to more productive farmers. This bias would result from the fact that a weighted average of water values is greatly influenced by the value of water to a few profitable water-use rights buyers.

[20] The average exchange rate reported by the Central Bank of Chile for June 1993 was used. This rate is Ch $403 = US $1.00.

There are some small transfers of water to developers of small residential and tourist housing along the valley and on the coast north of La Serena. The gains-from-trade from these transfers are higher than those for transfers to ESSCO. This reflects the fact that the value-of-water to the sellers of these shares is relatively low. The large gains-from-trade in intrasectoral trades reflects the high value of water to a few profitable farmers buying water-use rights.

Results of the financial analysis of individual rents in the Elqui Valley are presented in Table 8. The net rent to 14 individuals selling 491 shares of Elqui water averaged US $ 1,156 per share. In contrast, net rent to 18 buyers, purchasing 452 shares, averaged US $ 3,047 per share. In general individuals and firms buying water-use rights received larger net rents than water sellers. Intersectoral trades produced higher net rents than trades between farmers. The fact that many of the water-use rights sold in this valley were valued at zero because they were not employed by their owners at the time of sale, is a large factor in these high economic rents.

Table 8: Financial Analysis of Economic Rents to Buyers and Sellers: Elqui Valley

Elqui Valley	Number of Buyers or Sellers	Number of Shares	Mean Net Rent per Share U.S. $[a]
All Sellers	14	491	1,156
All Buyers	18	452	3,047
Individuals Selling to ESSCO	4	292	1,071
ESSCO	1	218[b]	3,104
Other Sellers of Intersectoral Transfers	3	32	1,041
Other Buyers of Intersectoral Transfers	6	40	4,890
Other Sellers	7	167	1,327
Other Buyers	11	194	2,603

a/ The June 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.
b/ Some of ESSCO's shares are reduced upon purchase by the Junta De Vigilancia de Río Elqui in order to account for conduction losses.

The Limarí Valley

South of the Elqui Valley in Region IV is the productive Limarí Valley, which contains the Río Limarí and its tributaries the Cogotí, Grande, Guatalame, Hurtado, and Rapel. This valley has 50,000 ha of irrigated farmland producing table grapes, pisco grapes, horticultural products, basic grains, and pasture (see ANNEX I and Map 2 in the Maps Section). A central feature of this valley is the presence of a large interconnected system of three interseasonal storage reservoirs: Paloma (750 million m^3), Cogotí (150 million m^3), and Recoleta (100 million m^3). This storage along with flexible gates and well organized WUAs allow for volumetric specification of water-use rights. This is a dry area with mean annual precipitation of 140 mm. There is one small city, Ovalle with a population of 80,000 that draws water from the Río Limarí.

In the Limarí Valley, a population of all water transactions was not developed. Instead, data collection was concentrated on areas with frequent transactions and individuals with many transactions. Attempts were made to balance interviews in these areas with other areas of less market activity. In the areas of the Río Hurtado and Río Grande which irrigate a total of 5400 ha above the Recoleta and Paloma Dams respectively, only a handful of transactions were identified. All other identified transactions were in areas below the reservoirs.

In this valley there is volumetric denomination of water-use rights based on the amount of water stored in the three main reservoirs[21]. Each WUA assigns a different amount of water to each share. Because of this all water-use rights were converted to an average volumetric denomination, based on survey results. These volumetric denominations are presented in Table 9.

The low transaction costs and frequent trades in the valley can be attributed to both modern infrastructure and well-developed WUAs. Because of reservoir storage and flexible gates, water is delivered to farmers on demand and a water transfer is almost costless. Thus, the frequency of transfer is high. Consequently, the market for water-use rights in this valley is active. Individuals easily separate water from land, and farmers make marginal water use decisions.

In total, 37 farmers selling water-use rights accounting for 2 million m^3/year were interviewed along with 19 buyers purchasing 7.2 million m^3/year. Another set of 16 farmers who purchased 965,220 m^3 of water on the spot market, (mostly during the 89-91 drought) were also interviewed.

[21] Because of the volumetric denomination, it is dangerous to directly compare the volume of water rights in the Elqui River to those of the Limarí Valley. In the former, 15,750 m^3 are delivered in an average year, but without regard to the time of delivery. In the latter, water is delivered to farmers at times that they request water.

Table 9: Estimated Volumetric Equivalencies of Shares: Limarí Valley

Water User Association	M^3 Per Year Per Share
AC Canal Camarico	3,000
AC Cogotí Reservoir	4,250
AC Canal Palqui-Maurat-Semita	45,000
JDV Río Limarí y Grande	7,000
JDV Río Guatalame	5,500
Ac Recoleta Reservoir	3,600

Results of the economic analysis of gains-from-trade in the Limarí Valley are presented in Tables 10 and 11. An average gross gains-from-trade of US $2.47 for each m^3/year transferred was estimated. After subtracting transaction costs the average net gains-from-trade is US $2.40 for each m^3/year. Net gains-from-trade in the spot market for volumetric purchases of water were US $ - 0.05. This is because water sold on the spot market is generally not used by its owner, and unused water is divided up among other water users[22]. Thus, on average, the value-of-water to farmers who purchased water on the spot-market is not much different from the weighted average of the value-of-water to other farmers in their part of the valley. Trades that involved the transfer of water to large grape producers produced higher net returns than other trades. But as shown in Table 13 these gains-from-trade are reduced considerably with a reduction in the export price of table grapes.

Results of the financial analysis of individual rents in the Limarí Valley are presented in Tables 12 and 13. Net rents to 37 individuals selling water rights, amounting to 1.7 million m^3/year averaged US $ 0.00 per m^3/year[23]. Net rents to 19 individuals purchasing water-use rights that deliver 7.5 million m^3 averaged US $1.78 m^3/year. The zero net rents to individuals selling water reflects the need of many farmers to sell their water-use rights to help make debt payments.

The spot market for a specific volume of water is active during dry years. According to WUA managers, the spot market is generally supplied by owners of shares of water not used in irrigation. This water is valued at zero to the seller. Net rent for 16 individuals purchasing 965,220 m^3 of water, mostly during the 89-91 drought, was US $ 0.08 per m^3.

[22] WUAs in the Limarí Valley generally do not allow farmers to save the water they receive for their water-use rights from one year to the next.

[23] The actual figure is - 0.0023.

Table 10: Economic Analysis of Gains-From-Trade: Limarí Valley Constant Table Grape Prices

Limarí Valley	Cubic Meters per year	U.S. $[a]
Total Gains-From-Trade	9,218,000	2.47
Net Gain-From-Trade	9,218,000	2.40
Net Gains-From-Trade on Spot-Market	965,220[b]	- .05
Total Gains-From-Trade Purchases of Large Table Grape Producers[c]	5,834,000	2.85
Net Gains-From-Trade Purchases of Large Table Grape Producers	5,834,000	2.84
Total Gains-From-Trade Other Purchases	3,384,000	1.81
Net Gains-From-Trade Other Purchases	3,384,000	1.65

a/ The June, 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.
b/ The spot market is for cubic meters of water not m^3 per year.
c/ Table grape producers with over 100 ha in production.

Table 11: Economic Analysis of Gains-From-Trade: Limarí Valley Export Price of Table Grapes Reduced 25 %

Limarí Valley	Cubic Meters per year	U.S. $[a]
Total Gains-From-Trade	9,218,000	0.58[b]
Net Gain-From-Trade	9,218,000	0.58[c]
Net Gains-From-Trade on Spot-Market	965,220[d]	- .05

a/ The June, 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.
b/ U.S. $ 0.584.
c/ U.S. $0.576.
d/ The spot market is for cubic meters of water not m^3 per year.

Table 12: Financial Analysis of Economic Rents to Buyers and Sellers: Limarí Valley Constant Table Grape Prices

Limarí Valley	Number of Buyers or Sellers	Cubic Meters per Year	Mean Net Rent per m^3/Year U.S. $
All Sellers	37	1,708,000	0.00
All Buyers	19	7,510,000	1.78
Individuals Selling to Large Table Grape Producers	20	857,000	0.08
Large Table Grape Producers	3	5,834,000	2.05
Other Sellers	17	851,000	- 0.08
Other Buyers	16	1,677,000	0.84
Buyers in Spot Market	16	965,000	0.04

a/ The June 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.
b/ The spot market is for one time purchases of m^3 not for m^3 per year.

Table 13: Financial Analysis of Economic Rents to Buyers and Sellers: Limarí Valley Export Price of Table Grapes Reduced 25 %

Limarí Valley	Number of Buyers or Sellers	Cubic Meters per Year	Mean Net Rent per m^3/Year U.S. $
All Sellers	37	1,708,000	0.02
All Buyers	19	7,510,000	0.24
Individuals Selling to Large Table Grape Producers	20	857,000	0.12
Large Table Grape Producers	3	5,834,000	0.27
Other Sellers	17	851,000	- 0.08
Other Buyers	16	1,677,000	0.16
Buyers in Spot Market	16	965,000	0.06

a/ The June 1993 exchange rate of Ch $ 403 = U.S. $ 1.00 was used.
b/ The spot market is for one time purchases of M^3 not for M^3 per year.

Rents to buyers are generally higher than those of sellers. And rents to large table grape producers — purchasing 78% of the water-use rights included in this analysis — are high relative to all sellers. This reflects the high value-of-water to these profitable farms. Although a 25%reduction of the export price of table grapes does reduce considerably the net rents to buyers of water, the rents received by large table grape producers is still relatively large. Much of this difference in individual rents from market transactions is due to the market power enjoyed by buyers. Since transactions prices are generally well known in these valleys, little advantage is derived from asymetric information.

Prices range from US $3,000 for a right with an average volume of 4,500 m^3/year in the table grape producing area above the Paloma Reservoir to US $500 for a share with the same volume below Paloma. This difference in price reflects both the premium placed on water in the hot, dry sunny uplands, and the prohibition on transferring water-use rights from below Paloma Reservoir to canals above the dam[24]. Also, the value of reservoir storage is demonstrated by the fact that a water-use right in the Limarí Valley is worth more than a water-use right in the Elqui Valley that delivers five times as much water.

Many of the permanent transfers of water-use rights in this area involves large acquisitions of both land and water by a few large table grape exporters. The land and transactions are generally reported separately because of the mobility of water rights in this valley. Some of these transactions entail a shift away from traditional crops to higher valued fruit crops. Also, in the last few years, many small and medium sized farmers have forfeited land and water rights to fruit exporting companies in lieu of debts owed to the companies.

The Maipo Valley

The first section of the Maipo River supplies water to 4.5 million people in the Santiago area as well as irrigates over 30,000 ha (see ANNEX I and Map 4 in the Maps Section). The river is divided into 8133 shares, each representing 8 liters/second, 85% of the time. In this first section of the river, there have been very few transactions of water-use rights in the past eight years (see ANNEX I). The Metropolitan Sanitation Works Company (EMOS) has contracted a team of lawyers to purchase rights but has purchased only 33 shares of the upper Maipo in the last eight years, with prices averaging US $10,000 per share. The only industrial concern to purchase water rights was a paper mill which made two purchases totaling 4.5 shares. There are also very few permanent trades between farmers. In the large canal systems of five WUAs, distributing 65% of the irrigation water in this section of the river, there were only a handful of trades between farmers. All of the canals serving these five WUAs have fixed flow dividers regulating the distribution of water.

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[24] Without this prohibition it would be relatively inexpensive to pump water directly from the Paloma Reservoir to the adjacent grape producing areas irrigated by upstream canals.

The Azapa Valley

The Azapa Valley, which is located in the downstream section of the San Jose River Basin in Chile's far north Region I, supports 3,280 acres of irrigated farmland and the city of Arica (population 160,000). This valley, bordering the extremely arid Atacama Desert, is very dry and rainfall in the lower reaches is negligible (see ANNEX I and Map 3 in the Maps Section). The Water Supply and Sanitation Company of Tarapaca (ESSAT), which supplies water to Arica, has been able to use rental agreements to meet the short term crude water needs of the city of Arica. ESSAT is renting wells from owners of groundwater rights. Various government agencies, responding to a presidential mandate to give Arica's water supply a priority in government action, have assisted in the process of renting wells. In the negotiations process, ESSAT was able to both invoke the government's appeal to farmers to release water for Arica and the possibility that the state could impound water during periods of severe water shortage. ESSAT has not needed to purchase water from users of a surface canal in the Azapa valley, because the groundwater supplies were made available. Thus the recent additions to Arica's water supply is much more a result of government action than of market activity.

In these arrangements ESSAT digs or rehabilitates a well, installs and operates a pump, delivers free-of-charge a few hours of water per week to the rights owner, and pays a rental fee for the use of the well. ESSAT will then pump water from the well continuously, whereas an irrigator would probably only use the water a few hours per week. This rental arrangement is quite lucrative to the individual irrigator, who does not absorb the negative externality of a depleted aquifer, at least in the short run. Since these rental contracts can be terminated by either party, it is probable that a few will be terminated after ESSAT receives water from the wells that are currently being rehabilitated in the Andean highlands.

V. OBSERVATIONS AND CONCLUSIONS

Water allocation institutions in Chile have a crucial role in the development of markets for water-use rights in local areas. Chile's heritage of privately developed irrigation, and its traditional allocation of river water by shares, has created a favorable climate for the establishment of transferable water-use rights. These rights have secured water supply to irrigators and thus provided an enabling environment for investment in permanent fruit crops and improved irrigation technology.

The overall growth in the value of Chile's agricultural output during the last decade can be attributed to various reforms in both input and output markets. The effects of the 1981 Water Code on the agricultural sector cannot be fully separated from the effects of liberalized trade and secured land rights. But, the agricultural sector that is highly dependent on irrigation has expanded without new investments in irrigation infrastructure. Chilean irrigators are also generally content with the codification of their traditional water-use rights. And since water-use rights are a tangible asset, which do not currently face a property tax, irrigators benefit from ownership of property rights even when the market for these rights is inactive.

This research has demonstrated that the market transfer of water-use rights does produce substantial economic gains-from-trade in both the Elqui and Limarí Valleys in north-central Chile. These economic gains occur in intersectoral trades and in trades between farmers, and they produce rents for both buyers and sellers. But buyers, especially large table grape producers in the Limarí Valley and individuals buying water-use rights for potable water supply in the Elqui Valley, receive higher rents then sellers. In the Elqui Valley total and net gains-from-trade per share were within the range of recent transfer prices of US $1,000 per share. In the Limarí Valley, gains-from-trade from shares of water-use rights are three times the recent transaction prices of US $3,000 for a share of water from the Cogotí Reservoir (one share delivers 4,250 m^3 in an average year).

One of the most interesting result of this analysis is the relatively modest economic gains from intersectoral trade in the Elqui Valley. Although, the value of water in municipal water supply is high, the value of water to profitable farmers is also high. When water is transferred away from these profitable farmers, the economic gains from this reallocation are small. Even if water is not used by its owner, it is generally used by other farmers. If these farmers are profitable, than the economic gains of the reallocation are small, even though the financial gain to the seller is large[25].

These four case studies (see ANNEX 1) demonstrate the diversity of water allocation and water management in northern and central Chile. In three of the four areas studied, especially where large canal systems use fixed flow dividers, market transactions were uncommon[26]. Despite the fact that these valleys were chosen for analysis because of expectations that they had

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[25] In most years, water is used by someone in the valley and is not wasted.

[26] These four valleys were selected for analysis because of prior information that there are active water markets.

relatively active local water markets, only the Limarí Valley had active trading. In this valley, transactions costs are low and trade between farmers are facilitated by the presence of reservoir storage, adjustable canal gates with flow meters, and well organized WUAs. In the Elqui Valley, the presence of many short canals flowing from the river also reduce the costs of physically changing the flow of water.

In large canal systems with fixed flow dividers, the cost of changing stream flows might be prohibitive especially for trades among farmers, as suggested by the scarcity of trading in the Canal Bellavista system in the Elqui Valley and the large canal systems in the upper Maipo Valley[27]. Indeed, outside of the Limarí basin farmers do not seem to make marginal decisions with water-use rights. Sales of marginal amounts of surplus water are far from typical. Investment decisions and crop selection have been based on the joint land/water allocation that resulted from the final stages of land reform[28].

Furthermore, WUAs play an important role in facilitating the market reallocation of water, especially in the Limarí Valley where trading is active and in the Elqui Valley where intersectoral trading occurs. Many of these WUAs have been able to adapt to the needs of their members for services that facilitate or impede transactions. One possible explanation for the lack of intersectoral trading in the Río Maipo is the failure of EMOS, the local municipal water supply company, to gain the cooperation of the *Sociedad del Canal del Maipo*, in its plans to purchase water-use rights.

The proposed Puclaro Dam project, on the Elqui River upstream of La Serena, is an example of how the presence of a market alternative to water allocation may reduce political pressure to invest in large water storage projects. This project has been proposed in different forms since 1956. As recent as 1989, potable water was considered to be the most important benefit of this dam. But when ESSCO did not agree to collaborate with the Directorate of Irrigation in paying for part of dam construction, the political importance of the dam declined.

This research demonstrated the economic and financial gains from using markets to reallocate water in the Elqui Valley instead of investing in a large water storage project. But it also showed how public investments in water storage and delivery systems in the Limarí Valley have the external benefit of reducing the transactions costs involved in market trading. In the presence of a system of transferable water-use rights further analysis of large water storage projects should consider the value of storage and adjustable gates in facilitating the reallocation of water.

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[27] When transactions occur in canals that are divided using fixed flow dividers (*marco partiadores*), it is necessary to measure and modify water flows through many of the individual fixed flow dividers within a canal system. For instance, if a tertiary canal delivered water to six farms (1,2,...,6) in succession, and farmer **2** sold water to farmer **6**, than fixed flow dividers to farms **2** through **6** would have to be modified and recalibrated by an engineer. If trades occur outside the tertiary canal the modifications become more complicated.

[28] In the final stages of land reform, land expropriated prior to 1974 was divided into family farms equivalent in value to 8 irrigated ha. Water rights traditionally assigned to the land were distributed to the land owners.

There is little danger that the current allocation of water-use rights will lead to the exploitation of urban water consumers. Indeed in the valleys of Elqui, Limarí, and Azapa, there is a general deference to urban water supply. Potential disputes are resolved in favor of municipal water supply without much conflict. One important reason for this is that in these areas there is little rural-urban competition. The urban areas of La Serena/Coquimbo, Ovalle, and Arica serve as service centers for the local agricultural areas. Most large irrigators and leaders of WUAs have houses and businesses in these communities, and don't want them to be short of water. Thus, in the Elqui Valley, ESSCO receives a priority on water delivery during periods when the Río Elqui is low. Also, in the Limarí Valley, ESSCO has received groundwater rights directly from the banks of the Río Limarí near Ovalle, without significant opposition from the JDV that manages this river. In the Azapa Valley, the aquifer is being rapidly depleted in order to supply water to the city of Arica. Despite the fact that water users have been able to avoid serious conflicts in these valleys, the absence of institutions for intersectoral discussion and conflict resolution is apparent.

In the Maipo, Elqui, and Limarí valleys, there was no indication that market allocation of water has contributed to environmental degradation, reduced water quality, or caused a decline in the use of return flows. In the Azapa valley, ESSAT's increased access to groundwater rights has led to an accelerated decline in aquifer storage. Despite this, there is little indication — from these case studies — that the 1981 Water Code needs to be modified in order to preserve the environment. However, accompanying Chile's economic growth is an increasing demand for environmental amenities, including fresh-water based tourism and recreation. Since many of these environmental amenities are public goods that are not well defined in a system of private property rights, efforts by either the DGA or the proposed river basin management corporations to protect the environment should prove to be beneficial.

The current 1981 Water Code does include some mechanisms to control certain negative externalities. The water code does not recognize the rights of users of return flows, and thus significantly endangers downstream users. But the DGA has the limited authority to deny permission to change river intakes. It could use this authority to limit any significant change in the location of water use that would adversely affect downstream users. Also, when aquifers are being drained by over pumping, the DGA has the authority to restrict the right to withdraw groundwater. It has done this in the Copiapo Valley, but not in the Azapa Valley due to the government's stated mandate of securing water for Arica.

One modification to the 1981 water code that could have a significant economic benefit is a property tax on water-use rights. Such a property tax on water-use rights could provide an incentive to increase the efficiency of water use, and would stimulate the reallocation of water in areas where individuals are holding rights for speculation or in a relatively low valued use. Also, this proposed tax would give the government the incentive to rapidly regularize all water-use rights and designate ownership of all shares.

The need for a flexible approach in the development of river management corporations is demonstrated in the Limarí Valley where WUAs are acting independently to try and form a river management company that will allow them to take control of the Paloma Reservoir. These WUAs have experience managing the Cogotí and Recoleta reservoirs and have demonstrated that they have the ability to manage large canal systems. But these WUAs have yet to accept the challenge of developing the hydroelectric generation capacity of their dams. This suggests that current WUAs, designed specifically to address the needs of irrigators, may lack the incentives needed to ensure sustainable intersectoral development, especially in the presence of interdependencies in consumptive and non-consumptive use.

Implications for Other Countries

This study has several important implications for other countries faced with water scarcity. First, there are significant gains-from-trade that can be realized by fostering water markets. These gains occur with both intersectoral trades and trades between farmers. Second, transferable water-use rights that are separate from land are an important requirement for water markets. These rights can be stipulated by volume or by percentage of river or canal flow. But in areas where water supplies are highly variable, it is necessary to designate how water is allocated during times of scarcity. Third, great care should be exercised in the initial allocation of water-use rights among users in order to make sure that all the rights are not captured by a few individuals. If an equitable distribution of land and water already exists, it is relatively easy to distribute water-use rights to the owners of land on which the water has been used. Fourth, proper technology and institutions such as adjustable gates and effective water user associations can substantially reduce transactions costs and facilitate market trading. Fifth, the presence of privately held water-user rights does not necessarily reduce the possibility of proper environmental management of rivers. Water quality regulations need to be established and enforced irrespective of the water allocation system. In Chile, where river valleys are relatively short, the quantity and quality of return flows may be less problematic than in other countries. Finally, within a decentralized system of water resource management there is a continuing role for water management authorities in enforcing rights and resolving conflicts. Yet if water-users and local authorities are able to resolve conflicts among themselves, they can avoid the need for intervention from an outside government entity.

Suggestions for Further Research

An analysis of intersectoral transfer of water-use rights should incorporate a study of land use patterns. This is especially true in expanding metropolitan areas, with significant suburban growth, where transfers of water-use rights from agriculture to the city tends to correlate with changes in land use. Also, changing land use patters may lead to situations, as in Santiago, where urban and suburban land continue to have irrigation water. Research on the value-of-water in urban irrigation would be a valuable component in a study of intersectoral water reallocation. These uses include the irrigation of public parks, as well as golf courses, gardens, and lawns. In Santiago the air quality benefits from urban irrigation that reduces the amount of dust and particulates in the air may be very high.

The full legal separation of water-use rights from land does not imply that irrigated land without corresponding water-use rights has the same value as dry land. The locational value of irrigated land, and its accessibility to irrigation water, is an important component in its value. An understanding of this locational value of irrigated land and dry land should be incorporated in further analysis of the economic gains from water markets.

By increasing the opportunity cost of water, water markets provide incentives for farmers to invest in technology to improve the efficiency of water use in agriculture. Research on farmers' response to this incentive over time would be a valuable addition to the water resources management literature.

Chile has relatively short rivers. This geographic fact has been offered as a possible explanation for the absence of serious environmental problems in these case studies. It is also may explain the feasibility of a system of water-use rights that do not acknowledge rights to return flows in downstream sections of rivers. Further studies, in other larger and longer river basins with a greater potential for environmental problems, would be an important contribution to our understanding of how geography may alter the need for environmental controls and rights for return flows.

Finally, research on water resources management in Latin America should include an analysis of mechanisms for reallocating water in a diverse set of river valleys in different countries. The water resources management system in Chile can be compared to those in other countries that do not have transferable water-use rights, or have less effective water user associations.

ANNEX I: CASE STUDIES

Introduction

Initially three river valleys were chosen for an economic analysis of water markets: the Elqui River, the Limarí River and the Maipo River. These rivers were chosen, with the assistance of Chile's *Dirección General de Aguas* (Directorate General of Waters). Because water scarcity is an important factor in the incentive to trade water-use rights, river valleys in southern Chile were avoided. The BíoBío Valley in south central Chile was not included in the analysis, because other studies were being conducted in that valley. Later, the Azapa Valley was included as a case study in order to investigate additional intersectoral transactions between irrigators and the local municipal supply company.

These case studies present general information of water resource use and management in these valleys. They also give important background information on market transactions that is useful in the development and understanding of the analyses presented earlier. Furthermore, these case studies elucidate many of the institutional issues that are important in water allocation.

THE FIRST SECTION OF THE MAIPO RIVER

The first, or upstream, section of the Río Maipo flows from the Andes mountain range through rich agricultural land to the community of Isla del Maipo southwest of Santiago[1]. This is a semi-arid region where average yearly precipitation is only 400 mm. The upstream section of the river supplies potable water for 4.5 million inhabitants of the Santiago metropolitan area, powers a few small hydroelectric plants, and provides a source of pleasant scenery and recreation near the city of Santiago[2]. The river also irrigates approximately 100,000 has of urban, suburban, and rural land. The major irrigated crops include permanent fruit crops such as kiwi, pears, peaches, and grapes as well as horticultural products, traditional grains, and pasture.

The first section of the Maipo is divided into 8133 shares, each representing at least 8 liter/second 85% of the time, with flows much larger during the critical months of December and January. Most of this water is used in agriculture, including 760 shares which cross the Mapocho River, a tributary of the Maipo, and irrigate lands to the north of Santiago. The *Junta de Vigilancia de Rio Maipo: Primera Sección* is responsible for supervising the distribution of water, but it remains mostly inactive. There are five large WUAs which, together with The Metropolitan Sanitation Works Company (EMOS), control 85% of Maipo's water in the first section (see Table I-1).

EMOS serving most of Santiago's populace, owns 1,369 shares. Most of these are withdrawn from the river at either EMOS' own intake gate or through the adjacent Canal San Carlos. Without the use of storage, EMOS's 1369 shares deliver 5.2 m^3/sec for the required

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[1] See Carvallo, undated, for information on this valley.

[2] Other sources of potable water for the Santiago area include the Mapocho River and groundwater.

Table I-1: Major Water Users in the First Section of the Maipo Valley.

Water User/ Water User Association	Number of Shares
Sociedad del Canal del Maipo	2,428
Asociación del Canal del Maipo	1,660
Canales Unidos de Buin	1,010
Canal Huidobro	650
Canal Pirque	630
EMOS[3]	565
Others	1,190
Total	8,133

95% security. But, EMOS owns both the El Yeso reservoir (255 million m^3) and Laguna Negra, a natural lake. Because of this storage capacity, EMOS's shares can deliver about 10 m^3/second at 95% security.

EMOS has made certain unsuccessful attempts between 1990 and 1993 to purchase Río Maipo water. EMOS claims that it has never refused an asking price, but has purchased only 33 shares of Maipo water, mostly from urban developers, with prices averaging US $10,000 per share[4]. EMOS is willing to accept the costs of changing fixed flow dividers, but because of the expense it is waiting to purchase a much larger quantity of rights before it physically transfers the water. In the past EMOS was able to extract water-use rights from urban land developers in exchange for connection to EMOS' water supply. A recent court ruling prohibits this practice. Thus, EMOS appears to be maintaining a passive role in the water market until it completes studies on groundwater development, on improved management of the El Yeso reservoir, and on lowering the intake at Laguna Negra. EMOS has estimated that it will need the equivalent of 3000 shares of Río Maipo water by the year 2020[5]. In the shorter term EMOS is scheduled to open a new water treatment plant in 1998, and it does not have the crude water supply to meet this plants capacity.

EMOS' most obvious source of sellers of water-use rights are urban canal users serviced by the *Sociedad del Canal del Maipo* (SCM). This organization delivers 1667 shares of Río Maipo water to mostly urban "irrigators" within the city of Santiago and 761 shares to farms on

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[3] EMOS also owns shares that pertain to other canals.

[4] Conversation with EMOS, June 1993.

[5] Conversation with EMOS Planning Department 11/93 and 2/94.

the north side of the Río Mapocho. These urban "irrigators" are owners of small plots in urban residential areas (the 1988 cadastre of the Maipo river has pages upon pages of these users, many of whom do not have legally inscribed rights[6]). Also, because the SCM is able to finance itself with a small (15,000 kw) hydroelectric plant, it does not charge these users for water delivery[7]. Thus, there is absolutely no demand management for a very large percentage of the upper Maipo River. It is also possible that some of these many water-use rights owners are unaware of their ownership. This canal system has adjustable water control gates and can easily move water from one area to another and provides water "on demand" without charges. SCM has purchased 1.16 shares of consumptive water-use rights in order to protect the flow of water through its hydroelectric plant[8]. EMOS itself belongs to the SCM, and it has placed its treatment plants below the SCM's hydropower plant.

There is a strong incentive for EMOS to seek the cooperation of SCM in its attempts to purchase Río Maipo user rights. EMOS can also negotiate with other large rights water-use rights owners such as the mining company *Disputada de Las Condes* which owns 153 shares that it apparently does not use and the Potable Water Company *Lo Castillo* which owns 135 shares which it holds in reserve and currently does not employ[9][10]. Given that EMOS can exploit a large aquifer downstream of Santiago, the current water situation in Santiago is not grave. However, in the presence of many low-valued urban "irrigators" and non-consumptive use, EMOS should be able to use the market more effectively than it has in the past to obtain new water supplies for its future needs.

One reason that EMOS might be slow in using market mechanisms to secure supplies of crude water, is its heritage as a state enterprise with certain prerogatives. For instance, there is the hope that in the case of chronic water shortage the government will interfere to assure EMOS's water supply. Another reason why sellers have not responded to EMOS's attempts to purchase water in the Maipo is the public knowledge of high prices recently paid to sellers of water-use rights in the Río Mapocho. In the Río Mapocho, the Potable Water Company *Lo Castillo*, which services Santiago's wealthy northeastern suburbs, has driven up the price of water rights. This water company has targeted for purchase the water rights that were traditionally used to irrigate land being urbanized in this area[11]. Lo Castillo has asked clients who want new water connections to turn over any water-use rights that are associated with their land. If they do not turn over these rights, water service is given, but for a higher price. Thus some prospective

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[6] *Dirección General de Aguas* 1988.

[7] Conversation with secretary SCM November 1993.

[8] Record of *Conservador de Bienes Raices* Puente Alto, Chile.

[9] Conversation with manager of *Lo Castillo* November 1993.

[10] Many of these shares were acquired in a September 1981 auction, by the D.G.A. of 313 shares of the first section of the Maipo River. At this auction, *Disputada de Las Condes* acquired 107 share; *Lo Castillo*, 80 shares; and EMOS, 26 shares.

[11] Conversation with Manager *Lo Castillo* June 1993.

clients purchased water-use rights to turn over to Lo Castillo's before asking for service. In 1993 Lo Castillo decelerated its buying program and began to investigate groundwater sources[12].

Throughout the upper Maipo Valley there is a reluctance of farmers to sell water-use rights. Indeed there are very few transactions of any kind. A total of 37.5 shares were transferred in intersectoral purchases made by EMOS and a paper mill. Interviews with the managers and directors of the WUAs - who would need to be involved if water is transferred from one place to another - have reported that there were: i) zero intra-agricultural trades in the Asociación del Canal del Maipo[13] system which delivers 25% of the river's irrigation water; ii) zero intra-agricultural trades in the Canal el Carmen system which delivers 6% of the river's water; and iii) only a handful of these trades in the systems of the United Canals of Buin, Canal Pirque, and Canal Huidobro which together deliver 34% of the area's irrigation water. All of these five canal systems use fixed flow dividers. The scarcity of transactions was confirmed by visits to both of the Real Estate Registries that serve this section of the river.

One reason for the lack of trading is the cost of physically changing canal flows through fixed flow dividers. This transactions cost makes marginal transfers of water expensive. Another possible reason is that farmers are comfortable with the current water/land input ratio which is a result of the last phases of the land reform. Furthermore, within the agrarian culture in this area, land and water continue to be seen as inseparable.

Temporary transactions between neighboring farmers have been known to occur in a few canal systems. According to WUA managers, these arrangements mostly involve a yearly use of a share of the river in exchange for payment of the yearly WUA service fee[14]. This type of arrangement occurs when a farmer withdraws from production, but does not wish to sell the water-use right because the value of the land would decline. The WUA may facilitate this type of transaction in order to ensure timely payment of the yearly service fee.

THE ELQUI VALLEY

All of the water in the Elqui Valley, except for water irrigating 1,500 ha, is controlled by the *Junta de Vigilancia de Rio Elqui* (JDVRE). This WUA delivers 25,000 shares of water to 118 canals along the Río Elqui and its tributaries the Río Claro, Río Cochiguaz, and Río Turbio. Most of these canals are quite small. One fifth of these shares remain inactive, since the owners do not pay fees to the JDVRE. This water is divided up among the remaining rights holders. Each share is supposed to deliver 1 liter/second of water, although in many years they deliver less[15]. The JDVRE also owns and controls the La Laguna Reservoir which stores 40 million

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[12] Conversation with Manager *Lo Castillo* November 1993.

[13] This is a different canal system from that of the *Sociedad del Canal del Maipo*.

[14] Interview Manager Canales Unidos de Buin, November 1993.

[15] Aninat, Mendez, and Merino, 1993 has reported that at 80% probability, a share of the Elqui River delivers 0.45 liters/second in May and 0.57 liters per second in January.

m^3. The *Dirección de Riego* has plans to construct a new dam at Puclaro with a reservoir capacity of 175 million m^3. The purpose of the Puclaro project is not to increase irrigated land, but to provide more security of water supply in dry years.

The Water Supply and Sanitation of Coquimbo (ESSCO), the water utility in the IV Region, currently owns 768 shares of the Rio Elqui. Of these, 280 shares pertain to the traditional water supply of the twin cities of La Serena and Coquimbo[16]. Another 270 shares were "expropriated" in 1986, when SENDOS, the government water supply service demanded the cessation of the water rights that pertained to land that was urbanized. It has made three major purchases totalling 218 shares (28% of ESSCO's current water supply) during 1992-93, and is in the process of transferring this water to its canal. One of these purchases is of water rights from areas that have recently been urbanized. Another purchase was from an individual who lost land in bankruptcy, but was able to protect the water rights. The third purchase was from a pair of grape producers who sold excess water, amounting to 60% and 70% of their shares, in order to invest in drip irrigation technology. ESSCO is confident that it can rely on the water market for its future needs, and plans to purchase 1,300 additional shares by 2020.

ESSCO has purchased water-use rights of the Elqui river in order to satisfy its crude water needs instead of investing in the proposed Puclaro Dam project. It has turned down an offer of 50 million m^3 of water storage sufficient for its required 95% security, at an investment price of US $20 million[17].

ESSCO is also investigating groundwater as a source of water to help meet the seasonal demand for water from the summer tourist population. ESSCO's water-use rights have a priority, and the water from their original water-use rights is not reduced proportionately in dry years. There is some confusion as to how many shares should receive this priority, but this confusion is somewhat inconsequential, because so far ESSCO has always received priority on all of its rights[18].

Two of ESSCO's transfers of water entail moving water from the point of purchase in the river to ESSCO's intake downstream. To account for losses during transfer, the JDVRE reduces these shares by one half percent for each kilometer of the transfer[19]. This calculation is not designed to account for return flows to the river, although average flows at points near the mouth of the river are higher than those at the convergence of the tributaries 80 kilometers upstream. This reduction in shares, for loss of water in transit, is a transactions cost that only ESSCO and one tourism developer have paid. As of 1993, ESSCO had not invested in modifying

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[16] Conversations with manager of JDVRE and planning department ESSCO, December 1993, and survey data.

[17] Conversation with *Dirección de Riego*, June 1993.

[18] If all of ESSCO's shares receive a priority, than this implies that all other users will receive even less water in dry years as ESSCO buys more shares.

[19] Thus the 218 "net shares" that ESSCO has purchased in the past few years were originally 292 "gross shares".

infrastructure. It has solicited permission from the regional *Dirección General de Aguas* to transfer the rights purchased. It has paid a lawyer 2% of purchase price to help in these transfers. The lawyer has also attempted to facilitate other purchases, but a few potential water-use rights transfers have been canceled because of insecure rights, and unsuccessful title searches[20].

ESSCO has played a leading role in the Río Elqui water market, but there are other transfers. Other transactions involve the transfer of water to large grape growers so that they can have a more secure supply of water. Also, there are some small transfers of water to developers of small residential and tourist housing along the valley and on the coast north of La Serena[21].

In one transaction, the transfer of water-use rights out of a canal caused a conduction externality that has limited the ability of water to flow through the canal. One irrigator sold his water-use rights because a neighboring farmer had previously sold shares and water flows through the canal no longer provided an adequate level of water for irrigation. Also, irrigators using Canal Herradura believe that the upcoming transfer of 7% of its water to ESSCO will significantly alter the ability of their canal to deliver water[22]. According to the WUA serving Canal Bellavista, the largest canal in the valley, which delivers 3,800 shares of water through a system of fixed flow dividers to 5,200 ha, there have been no transfers of water-use rights in this canal.

The importance of *Dirección General de Aguas*'s efforts to organize WUA's and regularize water- use rights is demonstrated by the confusion over water-use rights ownership in the area of the *Estero Derecho* of the Río Claro. Water in this tributary is not controlled by the JDVRE. In this area, which is ideal for grape production, some buyers and sellers of water rights suggested that their traditional rights have not been respected. Some records were reportedly destroyed in a fire. One result is a lot of distrust toward the local WUA. It is, therefore, difficult to buy and sell water-use rights in this area.

Irrigators in the Elqui Valley are generally satisfied with water quality, although many filter and add chlorine before using it for human consumption[23]. ESSCO does have problems with water quality, including heavy metals contamination. Both ESSCO and the regional public health service are monitoring Elqui river water, especially for iron, copper, arsenic, and cyanide which are characteristic of outflows from the mine of Minera El Indio into Rio Turbio[24]. ESSCO has a preliminary treatment plant for sewage waters, which it then releases into the sea. There are long term plans for more comprehensive treatment.

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[20] Conversations with manager ESSCO's planning department, December 1993.

[21] Survey data.

[22] Conversation with President AC Canal Herradura, December 1993.

[23] Survey data.

[24] Conversations with ESSCO and *Servicio del Salud de Coquimbo*, December 1993.

THE LIMARÍ VALLEY

The major part of the irrigation infrastructure in the Limarí Valley was provided by government-supported investment in irrigation infrastructure. Both the Cogotí and Recoleta reservoirs were built in the 1930s by the central government. They are both currently owned and operated by WUAs. Paloma was built in the 1960s by the national government and is currently owned and operated by the *Dirección de Riego*, in close cooperation with the WUAs that receive Paloma water. The *Dirección de Riego* also owns and operates the large trunk canal system connecting Paloma to canals of the individual WUAs. The Punitaqui Canal, a small secondary canal system constructed along with Paloma also belongs to the *Dirección de Riego*. Currently the *Dirección de Riego* provides this water to irrigators free of charge[25]. Except for the Punitaqui system, Paloma was built to provide more secure irrigation water to already developed irrigation systems, including those that receive water from Recoleta and Cogotí Reservoirs. For this reason, rights to water stored in Paloma have yet to be specifically designated to particular individuals and privatized, although this water is distributed to shareholders of the WUAs.

These WUAs are well organized and, together with the *Dirección de Riego* officials who operate the Paloma Dam and canals, cooperate in operating the interconnected system. These WUAs were established to service irrigators who use common sources of water (see Table I-2). Despite the fact that the government has yet to charge irrigators for the Paloma Reservoir and its canal system, the WUAs feel that they can operate the system better themselves. Because of this, efforts to turn over operation of the Paloma dam and canal system to the users were initiated by the WUAs in 1993 and, in principle, supported by the *Dirección de Riego*[26]. The irrigators and canal managers involved in these efforts feel that by establishing an autonomous enterprise to

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[25] Conversation with manager AC Canal Punitaqui.

[26] Conversation with WUA managers and Paloma Reservoir manager January 1994.

Table I-2: Major WUAs in the Limarí Valley.

Water User Association	Has Irrigated	Source of Water
JDV Río Grande y Limarí	13,107	Río Grande above Paloma Reservoir and Paloma Reservoir
AC Palqui-Maurat-Semita	2,200	Río Grande above Paloma Reservoir
JDV Río Cogotí	2,113	Río Cogotí above Cogotí Reservoir
AC Recoleta Reservoir	15,000	Río Hurtado Recoleta Reservoir and Paloma Reservoir
AC Cogotí Reservoir	12,000	Cogotí Reservoir and Paloma Reservoir
AC Camarico	5,500	Paloma Reservoir
JDV Río Guatalame	953	Cogotí Reservoir
AC Punitaqui	1,000	Paloma Reservoir
JDV Río Hurtado	3,325	Río Hurtado above Recoleta Reservoir

manage the Paloma system they can better develop the hydroelectric and tourist capacities of the dam and reservoir[27]. None of the three large dams in the Limarí Valley has a hydroelectric generation station.

Fees paid by irrigators to their WUAs vary considerably. Some charge a fixed fee for each share of water owned, some charge for each cubic meter of water delivered, and some charge for both[28]. Also, some WUAs require farmers to supply labor for maintaining primary and secondary canals, while others do not. Although distribution losses are a function of the distance between the water source and the farmgate, there are no extra fees for more remote water users. One WUA, the *Asociación del Canal Palqui-Maurat-Semita*, has purchased water-use rights in order to increase the amount of water it can distribute to its shareholders.

The reservoirs in this valley are interconnected, with Cogotí and Recoleta upstream of Paloma. It is very easy to transfer water from upstream to downstream sections of the river. But, because of storage limitations above Paloma, the transfer of water from below Paloma

[27] Currently a private individual owns the non-consumptive water-use rights that contain the potential power at the Paloma Dam.

[28] Conversations with WUA managers and survey data.

Reservoir to canals upstream has been prohibited. This is important since the highest valued use of water is in the production of table grapes in the hot, sunny uplands. One WUA is investing in a project to increase the security of water supply above Paloma, but this WUA will continue to prohibit transfers of rights from one area to another. It is also possible to keep in reserve shares of water in a WUA that charges low service fees, and transfer these shares to other canals to be used during dry years.

In this valley two important factors contribute to reduce transaction costs and facilitate market transfers of water. These are volumetric denomination of water-use rights, and well organized WUAs. Volumetric denomination involves both the preseason knowledge of availability of water, which is possible with 1,000 million m^3 of storage capacity, and the use of adjustable gates with flow meters throughout the system. The Cogotí and Recoleta Reservoirs are operated to provide water through a three year drought. The Paloma Reservoir has a greater storage capacity and after the last three year drought still had 1/3 of its capacity left in storage.

During April of each year, the WUAs, the *Dirección General de Aguas*, and the *Dirección de Riego* meet to determine the volumetric equivalent of each share based on actual storage and predicted rain. Depending on the WUA, in an average year shares deliver from 3000 to 7000 m^3. This system allows for the quick transfer of water on a short term basis - a spot market for water. Also, within certain limitations, water-use rights can be transferred permanently from one point to another with great ease. This wide range of transactions is possible because of the capacity of the WUAs to effectively operate the storage system and use flexible gates to deliver a reliable supply of water.

ESSCO, which as a regional water supply company supplies water to the city of Ovalle, pumps water directly from the banks of the Limarí River, using groundwater rights granted by the regional *Dirección General de Aguas*. The grant of groundwater rights was initially unopposed by the *Junta de Vigilancia de Río Limarí*, which believed that the *Dirección General de Aguas* was only granting permission for an experimental well. Given this source of water there is little incentive for ESSCO to acquire new water-use rights for the city of Ovalle.

In the past three years there has been a rapid accumulation of land and water rights by large fruit exporters, especially in the area of El Palqui, upstream of and adjacent to the Paloma Reservoir. This accumulation is in contrast with the gradual consolidation of land and water rights that has taken place in much of Chile in the years subsequent to land reform. In the last few years, many small and medium sized farmers have forfeited land and water rights to fruit exporting companies in lieu of debts owed to the companies[29].

In the Limarí area there are four or five major fruit exporters. Most of these, including the largest (Unifrutti), is multinational. Small scale producers enter into financing and marketing contracts with these firms. The contracts are for a fixed multiyear period. The company provides financing for land preparation and high technology drip irrigation, technical assistance, and agricultural inputs. The contract specifies that the debt be paid in grapes, priced according

[29] Interviews with table grape growers.

to Philadelphia market prices. A producer is not free to sell to rival exporters until his/her debt is paid.

The production of table grapes was very profitable from 1984-91. But low prices, poor harvests, and the seemingly continual expansion of production has reduced profitability. Some scale small producers are willing to accept the blame for their loss. Many bought vehicles with the loans. Others say that large producers receive favorable marketing treatment. Low grape prices in 1992 and 1993 created financial problems for many small producers, and their resulting forfeiture of land and water use-rights has allowed the export firms to consolidate both water and land holdings.

In this valley, low transaction costs and frequent trades can be attributed to both modern infrastructure and well-developed WUAs. Because of reservoir storage and flexible gates, water is delivered to farmers on demand and a water transfer is relatively costless. Thus, the frequency of transfer is high. Consequently, the market for water-use rights in this valley is active. Individuals easily separate water from land, and farmers make marginal decisions on water use.

Many of the permanent transfers of water-use rights in this area involves large acquisitions of both land and water by a few large table grape exporters. The land and transactions are generally reported separately because of the mobility of water rights in this valley. Some of these transactions entail a shift away from traditional crops to higher valued fruit crops.

THE AZAPA VALLEY

The Azapa Valley supports 3,280 acres of irrigated farmland and supplies water to the city of Arica[30]. Arica is a commercial and tourist center, with a small fishmeal processing industry and clothing factories. Two sources of surface water for this valley include an interbasin transfer of water from the Andean highlands through the Azapa Canal, which currently averages 796 liter/second, and small springs, which have an average flow of 305 liter/second. Both of these flows are diverted to the Azapa Canal for irrigation. Also, the Azapa Valley contains an unconfined aquifer with 180 wells extracting an estimated existing total storage of 302 million m^3 in 1993.

Parallel, and in close proximity to the Azapa Valley is the Río Lluta, one of the few in northern Chile to have a constant flow. Unfortunately, water in this river has a high degree of natural contamination (salt, boron, sulphur, and sulfates) and is only fit for irrigating pasture, maize, and onions[31]. Other small sources of brackish water on the coast north of Arica are used by Arica's textile industry.

In the Andean highlands near Bolivia, another relatively moist basin feeds Lake Chungurá, the highest lake in the world, and the Río Lauca which drains into Bolivia. This is a unique and fragile ecosystem which supports the Lauca National Park and is home to pastoral

[30] See Japan International Cooperation Agency, 1993 for information on this valley.

[31] Conversation with Secretary JDV Río Lluta, February 1994.

Aymara Indians. Since 1962 water from this basin was diverted, at Lake Cotacotani, through the Lauca Canal to a hydroelectric station at Chapaquina to irrigators in the Azapa Valley. A more recent project to transfer water from Lake Chungara was physically completed and later enjoined from operation after a legal suit was won by an environmental interest group[32]. A separate project to rehabilitate wells in national park land in the highlands is under development in order to increase the water supply for the city of Arica. This project was not opposed by the *Corporación Nacional Forestal* (National Forest Company) which manages the park.

Irrigated crops in the Azapa Valley include olives and horticultural products. The latter is grown largely in greenhouses with drip irrigation. These crops are sold at a premium price because they can reach the market in Santiago before other supplies. Olives are exported to the world market directly from Arica[33].

Irrigators who receive water from the Azapa Canal belong to the *Comunidad de Aguas del Canal Azapa* (COMCA). This WUA has recently received its legal charter. Until 1989, the Canal Azapa was managed by the *Dirección de Riego*, but water-use rights for this water have been distributed, and COMCA is in the process of purchasing the Canal Azapa from the government[34]. The Lauca Canal is still managed by the *Dirección de Riego*. The WUA which controls the Río Lluta, the *Junta de Vigilancia del Río Lluta*, was in the process of receiving its legal charter in 1994. While it was in the process of obtaining its charter, this WUA did not permit transfers of water-use rights.

Until 1993 the city of Arica faced a severe water shortage. In some areas of the city, residents received water for only a few hours of the day. The government then declared that potable water supply was to be a governmental priority, and different mechanisms were put in place to ensure the short and medium term supplies of crude water for The Water Supply and Sanitation Company of Tarapaca (ESSAT), the regional water utility. The central government released capital for ESSAT to finance an expansion of its water supply. The *Dirección General de Aguas* "discovered" unused wells for ESSAT to exploit via rental. The *Dirección de Riego* allowed ESSAT to use the *Dirección de Riego*'s wells, without payment, until further supplies were secured[35]. In addition, ESSAT was allowed to significantly increase groundwater pumping in the Azapa Valley, despite recent indications that the Azapa aquifer was being drained at an alarming rate.

The depletion of the Azapa aquifer is a matter of great controversy. A recent study has concluded that at current withdrawal and recharge rates the remaining life of the groundwater

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[32] Conversations with DGA, DR, and *Corporacion Nacional Forestal* officials, February 1994.

[33] Conversations with irrigators, February 1994.

[34] Conversations with COMCA manager February 1994.

[35] Conversation with ESSAT, February 1994.

storage is less than 20 years[36]. Farmers in the valley have complained of increased costs of pumping water from the aquifer, and the reduced flows in the valley's springs. The *Dirección General de Aguas* does have the authority to impose restrictions and limitations on water extractions from aquifers that are determined to be in danger of depletion[37]. But, given the government's stated priority on potable water supply, the *Dirección General de Aguas* is not likely to act to limit ESSAT's pumping.

The success of ESSAT in increasing the supply of water available to the city of Arica can be attributed to the government's political desire to bring water to the city. This government action demonstrates the flexibility of the 1981 Water Code, and the reluctance of the government to use its powers of emergency expropriation. And although the local water market has been used to enable ESSAT to increase its short-term supply of water, there is a noted absence of permanent, market transfers of high quality water from the Azapa Canal to ESSAT.

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[36] Japan International Cooperation Agency, February 1994.

[37] It has done this in the Copiapo Valley.

ANNEX II: REPRESENTATIVE CROP BUDGET

Table II-1: Pisco Grapes

Field Type[1] - 3 Ha. Pisco Grapes, Furrow Irrigation
- Paihuano, Elqui, IV Region, Chile
- with 25 Shares of Water from Río Elqui

			Thousand $ Chilean Peso[2]
Total Revenue 30,000 kg/ha * 80[3] $/kg * 3 ha			7,200
Cost			
Machinery	48,000	$/ha	
Labor 86.2 days * 1500 $/day	129,300	$/ha	
Inputs	239,882	$/ha	
Total 3 ha *	4,171,82	$/ha	(1,252)
Cost of Water Delivery[4]			(74)
Intraseasonal Finance 50% of costs * 6 months @ 15%			(50)
Net Revenue			5,824
minus 7% management	(406)		5,418
minus land tax 10% of 50% stated value	(450)		4,968
minus debt service for crop development and drip irrigation installation 3 year disbursement, 3 year grace, 19 year payment @ 15%	(2,219)		2,749
Net Returns to Land and Water	2,749		
minus 22% relative value of land	(605)		2,144
Net Return per Water Right			86
Present Value of Water Rights @ 12% interest, 50 year term			712

[1] Farm, yield, water, and land information taken from survey data.

[2] The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

[4] Survey data on fees paid to WUAs for water delivery and labor contributed to clean exterior canals. Figures reported in 1993 terms were initially deflated to correspond to the rest of the cost information.

Table II-2: Tomato

Field Type[1] - 2 Ha. Tomatoes, Furrow Irrigation
- Ovalle, Limarí, IV Region, Chile
- with 2.4 Shares of Water from Canal Camarico

			Thousand $ Chilean Peso[2]
Total Revenue 52[3] $/kg * 2 ha * 25,000 kg/ha			2,600
Cost			
Services	89,640	$/ha	
Labor 134.4 days * 1500 $/day	201,600	$/ha	
Inputs Fertilizer	44,400	$/ha	
Pesticide	102,897	$/ha	
Other	643,572	$/ha	
Finance	44,268	$/ha	
Total 2 ha *	1,126,377	$/ha	(2,253)
Cost of Water Delivery[4]	41	$/ha	(41)
Net Revenue			306
minus 7% management	(21)		285
minus land tax 10% of 50% stated value	(70)		215
Net Returns to Land and Water			215
minus 27% relative value of land	(79)		136
Net Return per Water Right			56
Present Value of Water Rights @ 12% interest, 50 year term			468

[1] Farm, yield, water, and land information taken from survey data.

[2]The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

[4] Survey data on fees paid to WUAs for water delivery and labor contributed to clean exterior canals. Figures reported in 1993 terms were initially deflated to correspond to the rest of the cost information.

Table II-3: Corn

Field Type[1] - 1 Ha. Corn, Furrow Irrigation
- Ovalle, Limarí, IV Region, Chile
- with 2 Shares of Water from Cana'l Camarico

			Thousand $ Chilean Peso[2]
Total Revenue 5,000 kg/ha * 5[3] $/kg * 1 ha			250
Cost			
Machinery	25,000	$/ha	
Labor 7.7 days * 1500 $/day	11,550	$/ha	
Inputs Fertilizer	31,300	$/ha	
Herbicide	11,330	$/ha	
Other	26,570	$/ha	
Total ha *	105,750	$/ha	(106)
Cost of Water Delivery			(3)
Intraseasonal Finance 50% of costs * 6 months @ 15%			(4)
Net Revenue			137
minus 7%	(10)		127
minus land tax 10% of 50% stated value	(100)		27
Net Returns to Land and Water			27
minus 48% relative value of land	(14)		13
Net Return per Water Right			7
Present Value of Water Rights @ 12% interest, 50 year term			58

[1] Farm, yield, water, and land information taken from survey data.

[2]The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

Table II-4: Chile Pepper

Field Type[1] - 2 Ha. Chile Pepper, Furrow Irrigation
- Ovalle, Limarí, IV Region, Chile
- with 5 Shares of Water from Canal Camarico

				Thousand $ Chilean Peso[2]
Total Revenue	1,000 kg/ha * .5[3] $/kg * 2 ha			1,000
Cost				
Machinery		22,800	$/ha	
Labor 132	days * 1500 $/day	198,150	$/ha	
Inputs Fertilizer		31,950	$/ha	
Insecticide		36,950	$/ha	
Seeds		85,000	$/ha	
Total 2 ha *		374,850	$/ha	(749)
Cost of Water Delivery				(42)
Intraseasonal Finance	50% of costs * 6 months @ 15%			(28)
Net Revenue				181
minus 7% management		(13)		168
minus land tax 10% of 50% stated value		(50)		118
Net Returns to Land and Water				118
minus 23% relative value of land		(26)		92
Net Return per Water Right				19
Present Value of Water Rights	@ 12% interest, 50 year term			158

[1] Farm, yield, water, and land information taken from survey data.

[2]The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

Table II-5: Potato

Field Type[1] - 2 Ha. Potatoes, Furrow Irrigation
- Ovalle, Limarí, IV Region, Chile
- with 3.3 Shares of Water from Río Limarí

			Thousand $ Chilean Peso[2]	
Total Revenue 13,000 kg/ha * 44[3] $/kg[4] * 2 ha			1,144	
13,000 kg/ha * 59.5 $/kg[5] * 2 ha			1,547	
Total			269	
Cost Summer Winter				
Services	60,725	$/ha	36,941	$/ha
Labor	83,520	$/ha	72,000	$/ha
Inputs Fertilizer	52,272	$/ha	49,020	$/ha
Pesticide	40,115	$/ha	29,545	$/ha
Other	278,863	$/ha	299,471	$/ha
Finance	21,088	$/ha	13,281	$/ha
Total	536,583	$/ha	500,257	$/ha
1,036,840 $/ha * 2 ha			(2,074)	
Cost of Water Delivery			(6)	
Net Revenue			611	
minus 7%	(42)		569	
minus land tax 10% of 50% stated value	(100)		469	
Net Returns to Land and Water			469	
minus 62% relative value of land	(290)		179	
Net Return per Water Right			54	
Present Value of Water Rights @ 12% interest, 50 year term			448	

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[1] Farm, yield, water, and land information taken from survey data.

[2] The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

[4] Summer Harvest.

[5] Winter harvest.

Table II-6: Alfalfa

Field Type[1] - 5 Ha Alfalfa, Flood Irrigation
- Ovalle, Limarí, IV Region, Chile
- with 6.7 Shares of Water from Recoleta Reservoir

			Thousand $ Chilean Peso[2]
Total Revenue 9.5[3] $/kg * 5ha * 18,000 kg/ha			855
Cost Maintenance			
Machinery	26,400	$/ha	
Labor 6.4 days * 1500 $/day	9,600	$/ha	
Total	36,000	$/ha	
Cost Planting			
Machinery	9600	$/ha	
Labor 6.7 days * 1500 $/day	10095	$/ha	
Inputs Fertilizer	9,000	$/ha	
Seeds	17,600	$/ha	
Total	46,295	$/ha	
Average Cost over Four Years 5 ha *	38,574	$/ha	(193)
Cost of Water Delivery	42	$/ha	(42)
Net Revenue			620
minus 7% management	(43)		577
minus land tax 10% of 50% stated value	(375)		202
Net Returns to Land and Water	202		
minus 85% relative value of land	(165)		37
Net Return per Water Right			6
Present Value of Water Rights @ 12% interest, 50 year term			46

[1] Farm, yield, water, and land information taken from survey data.

[2] The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

Table II-7: Wheat

Field Type[1] - 4 Ha. Wheat, Flood Irrigation			
- Ovalle, Limarí, IV Region, Chile			
- with 4 Shares of Water from Canal Camarico			
			Thousand $ Chilean Peso[2]
Total Revenue 3,200 kg/ha * 79[3] $/kg * 4 ha			1,011
Cost			
Machinery	29,350	$/ha	
Labor 6.4 days * 1500 $/day	9,600	$/ha	
Inputs Fertilizer	22,720	$/ha	
Other	7,600	$/ha	
Seeds	10,400	$/ha	
Total 4 ha *	69,670	$/ha	(279)
Cost of Water Delivery	39	$/ha	(39)
Intraseasonal Finance 50% of costs * 6 months @ 15%			(10)
Net Revenue			683
minus 7% management	(48)		635
minus land tax 10% of 50% stated value	(167)		468
Net Returns to Land and Water			468
minus 55% relative value of land	(259)		209
Net Return per Water Right			54
Present Value of Water Rights @ 12% interest, 50 year term			448

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[1] Farm, yield, water, and land information taken from survey data.

[2] The June 1993 exchange rate of US $ 1.00 = Ch $403 was used.

[3] Input and output prices are taken from representative crop budgets used in Direccion de Riego analyses. Crop budgets reflect 1991 prices that are later inflated to represent June 1993 values. Cost of water delivery, which was reported in 1993 terms was deflated to correspond to the 1991 prices.

ANNEX III: SURVEY INSTRUMENT

SURVEY INSTRUMENT

NOMBRE: ____________________

DIRECCION: ____________________

COMUNA: ____________________

TRANSACCION: ____________________

____

____

____

CASO DE ESTUDIO: ____________________ [ ]

ENCUESTADOR: ____________________ [ ]

NUMERO DE ENCUESTA: [ ] [ ]

1a. Cuántas Has. tiene su predio? 1a.________

1b. Cuántas Has. tiene Ud. en producción? 1b.________

1c. Cuántas de éstas es tierra propia? 1c.________

1d. Cuánto es tierra arrendada? 1d.________

1e. Cuánto da en arriendo? 1e.________

1f. Ha cambiado en los últimos diez años la superficie que cultiva Ud.? 1f. Sí No

(Si respuesta es sí, se sigue con 1g)

1g.

Año	Has.	Tipo de Transacción	Precio Total (M Pesos)

* Especifique compra = C, venta = V, arriendo = A, dado en arriendo o tiempo de arriendo.

2. Cuáles son sus cultivos principales?

Cultivo	Ha.	Tipo de Riego *	% de Agua
Otro			

* Tendido = T Surcos = S Aspersión = A Californiano = C
Goteo = G Microjet = M Secano = N

3. De estos cultivos que rendimiento espera Ud.?

Cultivo	Año Promedio	Año Bueno	Año Malo

4a. Ha cambiado su estructura productiva en los últimos diez años?

4a. Sí No

[Si es sí, sigue con 4b. y 4c.]

Cultivo	Ha.	Tipo de Riego *	% de Agua

*	Tendido = T	Surcos = S	Aspersión = A	Californiano = C
	Goteo = G	Microjet = M	Secano = N	

Cultivo	Ha.	Tipo de Riego*	% de Agua

*	Tendido = T	Surcos = S	Aspersion = A	Californiano = C
	Goteo = G	Microjet = M	Secano = N	

5. Cuántas acciones o derechos de agua tiene Ud. actualmente?

Nombre del Canal o Río	No. de Acciones	Permanentes o Eventuales

6a. Cuántas horas le permite recibir agua sus derechos o acciones en año promedio?

	No. horas cada riego		No. horas cada riego
Agua Permanente		Agua Permanente	
Diarias		Diarias	
Dos veces/semana		Dos veces/semana	
Semanales		Semanales	
Quincenales		Quincenales	

6b. Con qué sistema se parcializa el agua que Ud. recibe de su canal principal? 6b.______

[especifique, Compuertas con Regales = CR Compuertas sin Regales = CS
Marcos Partidores = MP Otros (especifique)]

6c. Cuántos regantes comparten el ramal del canal con Ud.? 6c.______

6d. Dentro de su ramal del canal cuántos regantes hay entre la bocatoma y el marco partidor o compuerta de su predio? 6d. Sí No

6e. Recibe Ud. todo el agua que necesita durante un año promedio? 6e.______

6f. Cuánto estima Ud. que vale una accion? 6f.______

6g. A su juicio, cuántas acciones debiera tener para satisficer sus necesidades de riego? 6g.______

6h. Cuánto es el valor mínimo al que estaria dispuesto a vender una acción? 6h.______

7. Ha cambiado en los últimos diez años la cantidad de acciones o derechos o regadores que le pertenecen?

7a. Sí No

[Si respuesta 7a. es Sí sigue 7b. y 7c.]

7b.

Año	No. de Acciones	Tipo de Transacción	Precio Total

* Especifique compra, venta, arriendo, dado a arrendar y canal de la pregunta No. 5. Si arriendo o dado a arrendar determine por cuánto tiempo?

7c. Por qué cambio su cantidad de acciones?

7c.____

8. Nos gustaria saber si estas transacciones le han involucrado algún costo adicional, por ejemplo:
A qué costo?

8a. Fue necesario obtener inscripciones legales de sus derechos del estado? 8a. Sí No 8b.________

8c. Tuvo que contratar un abogado para ayudarle? 8c. Sí No 8d.________

8e. Tuvo que contratar un notario para ayudarle? 8e. Sí No 8f.________

8g. Tuvo que contratar un ingeniero para ayudarle? 8g. Sí No 8h.________

8i. Tuvo que contratar algún otro especalista para ayudarle? 8i. Sí No 8j.________

8k. Cuánto tiempo le tomó el proceso? 8k.________

8l. Le significó un gasto personal ese tiempo? 8l. Sí No 8m.________

8n. Tuvo que cambiar marcos partidores o compuertas a costo suyo? 8n. Sí No 8o.________

8p. Tuvo que realizar una ampliación del cauce del canal? 8p. Sí No 8q.________

8r. Tuvo que pagar indemnización a otros canalistas? 8r. Sí No 8s.________

9a. De dónde obtuvo la información necesaria para encontrar el comprador (vendedor) y para ayudarle en las negociaciones?

9a. ____

9b. Cuánto le costó? 9b.________

10a. Pertenece Ud. a una asociación de canalistas o comunidad de aguas? 10a. Sí No

10b. Qué costo anual le representa a Ud. pertenecer a esta organización, en terminos de dinero? 10b.________

10c. Qué costo anual le representa a Ud. pertenecer a esta organización en términos de ayuda en mano de obra? 10c.________

10d. Quién limpia y mantiene su canal? 10d.________

10e. Su organización le ayudó en su transaccion de derechos? 10e. Sí No

10f. Su organización le dificultó en su transacción de derechos? 10f. Sí No

11a. Tiene Ud. algún pozo? 11a. Sí No

11b. Qué uso tiene el agua de este pozo? 11b.________

11c. Lo usa todo el año o solamente cuando no hay agua en el canal? 11c.________

11d. Cuál es el flujo de agua que obtiene de este pozo? 11d.________

11e. En que año hizo el pozo? 11e.________

11f. Cuánto le costó hacer el pozo? 11f.________

11g. Qué costo de manutención anual tiene el pozo? 11g.________

11h. Qué costo de operación anual tiene el pozo? 11h. ________

11i. Fue necesario solicitar derechos o incripciones de aguas subterráneas? 11i Sí No

11j. Cuánto le costó? 11i.________

12. De dónde proviene su agua potable? 12.________

13a. Ha hecho Ud. inversiones para mejorar la eficiencia del riego en su predio? 13a. Sí No

13b. Cuáles? 13b.________________________________

13c. Cuándo? 13c.________________________________

13d. En qué superficie? 13d.________________________________

13e. Para cuáles cultivos? 13e.________________________________

13f. Por qué 13f.________________________________

13g. Cuánto le costó? 13g.________________________________

14a. Tiene Ud. un tanque de acumulación? 14a. Sí No

14b. Cuándo lo hizo? 14b.________

14c. De qué capacidad es? 14c.________

14d. Cuánto le costó? 14d.________

15a. Cómo se clasifican sus suelos? 15a.________

15b. Ha cambiado el valor de la hectárea de su tierra en los últimos diez años? 15b. Sí No

15c. Cómo cambió? 15c.________________________________

15d. Por qué cree Ud. que cambió?

15d. ____

15e. Qué valor tiene su hectárea actualmente? 15e.__________

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MAP 1

CHILE
WATER RESOURCES IN CHILE

CITIES OVER 50,000 INHABITANTS
- ● 50,000 - 100,000
- ▲ 100,000 - 300,000
- ■ 300,000+

- CASE STUDIES
- CENTRAL VALLEY
- PORTS
- ADMINISTRATIVE REGION BOUNDARIES
- INTERNATIONAL BOUNDARIES

0 200 400 600 800 KILOMETERS

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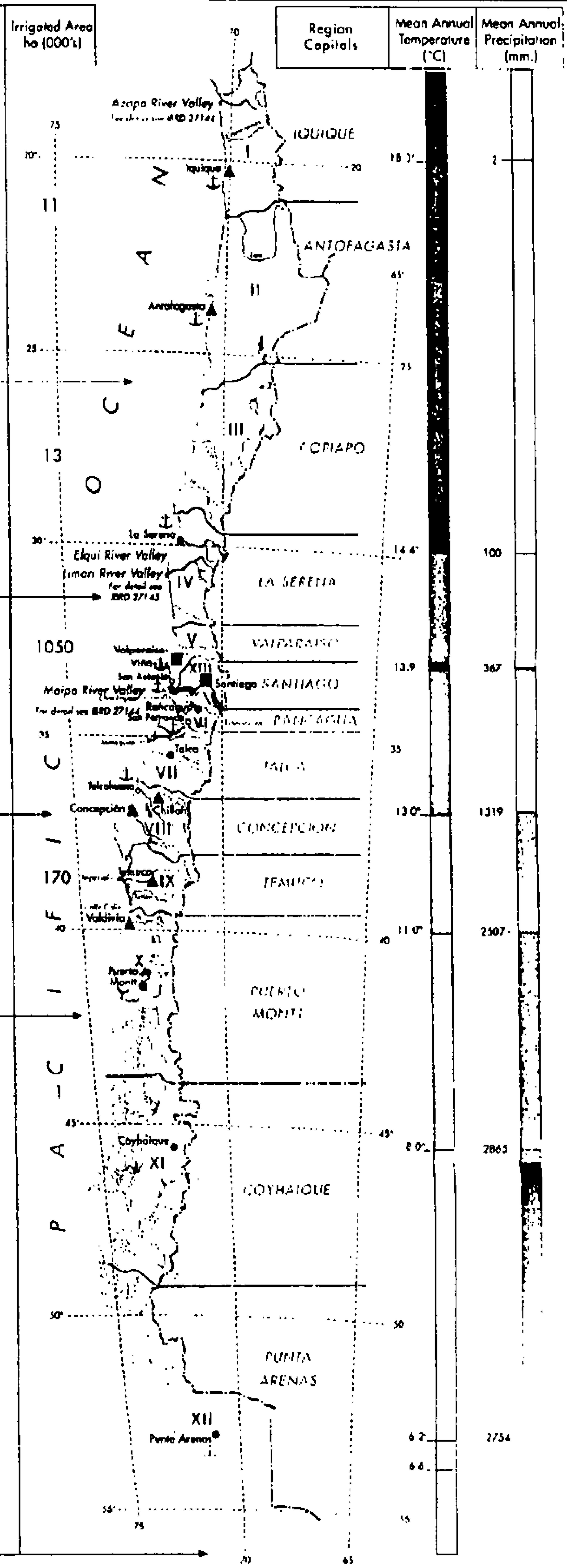
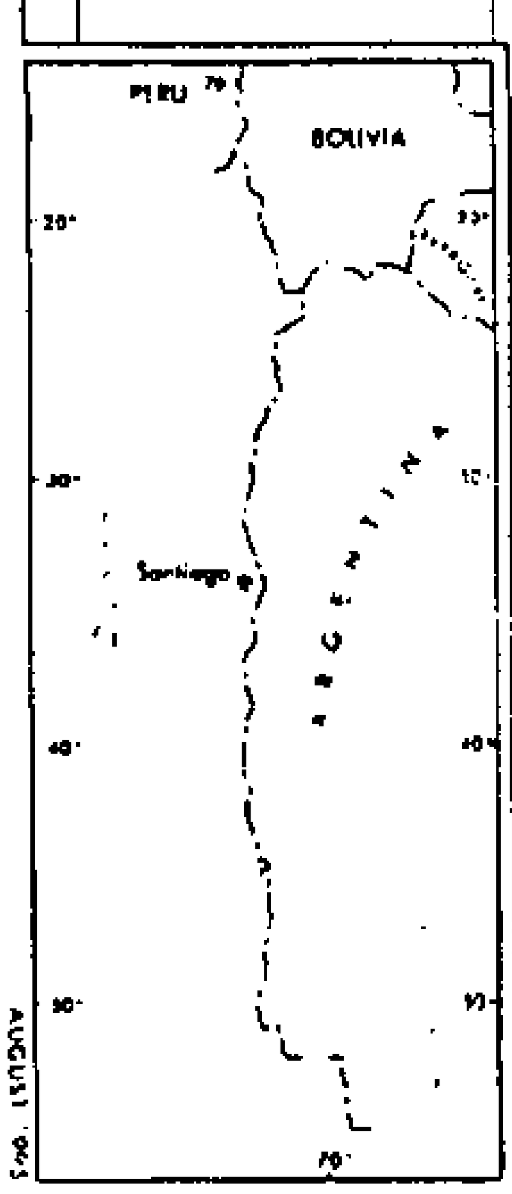
Agricultural Production	Zone	Total Area km² (000's)	Crops and Pastures ha (000's)	Irrigated Area ha (000's)
Irrigated oases and river valleys	I Desert	178	13	11
Irrigated river valleys and oases, itinerant sheep and goats	II Arid	120	195	13
Fruits, vegetables, grapes, wheat, maize, milk, sunflower, beef, cattle, sheep, sugar, pulses, forestry	III Mediterranean	93	2160	1050
Cattle, milk, sheep, forestry, barley, oats, potatoes, fruits, sugarbeets, pulses, wheat	IV Temperate	102	2990	170
Sheep, cattle, forestry	V Humid	248	185	





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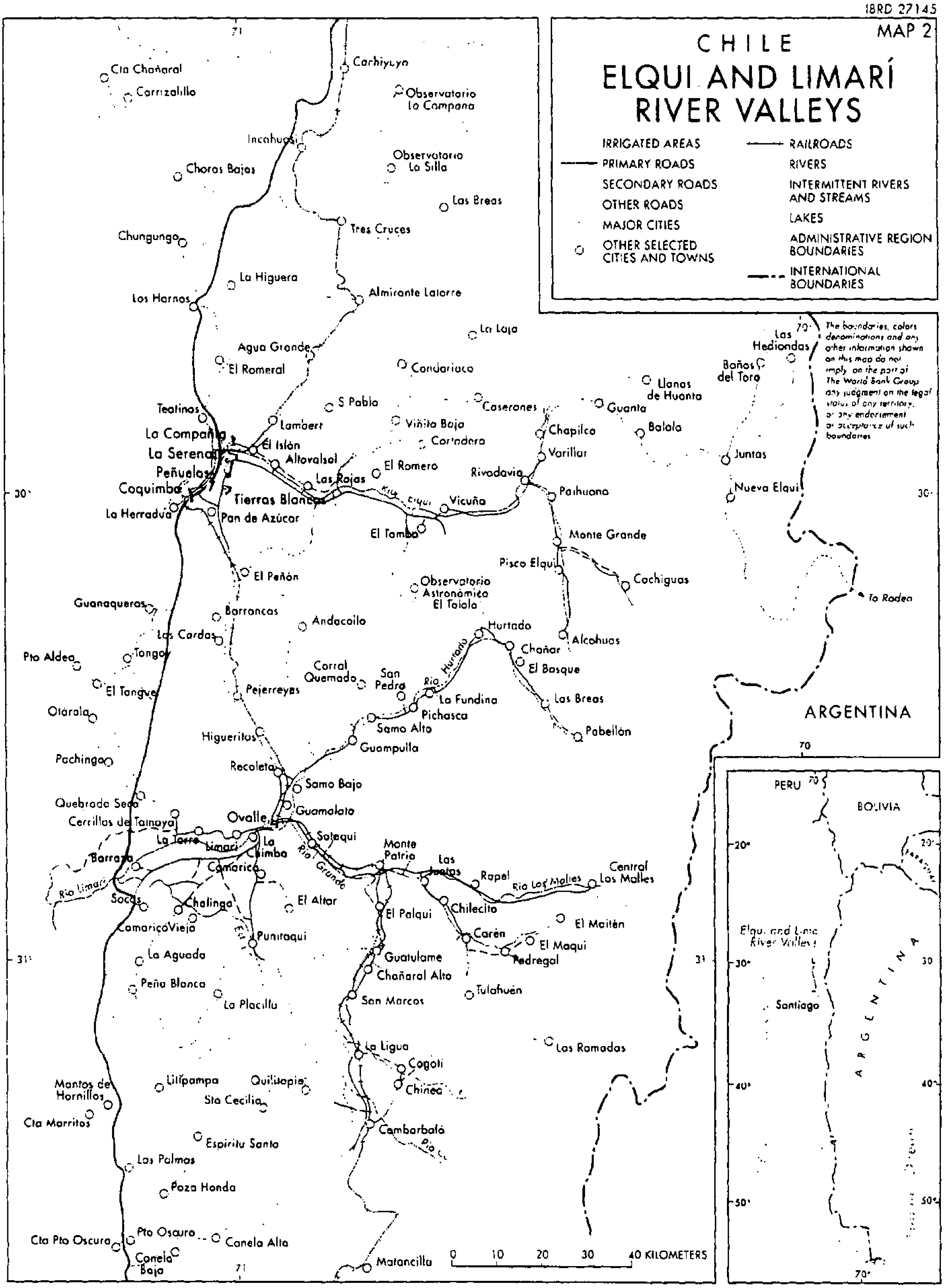

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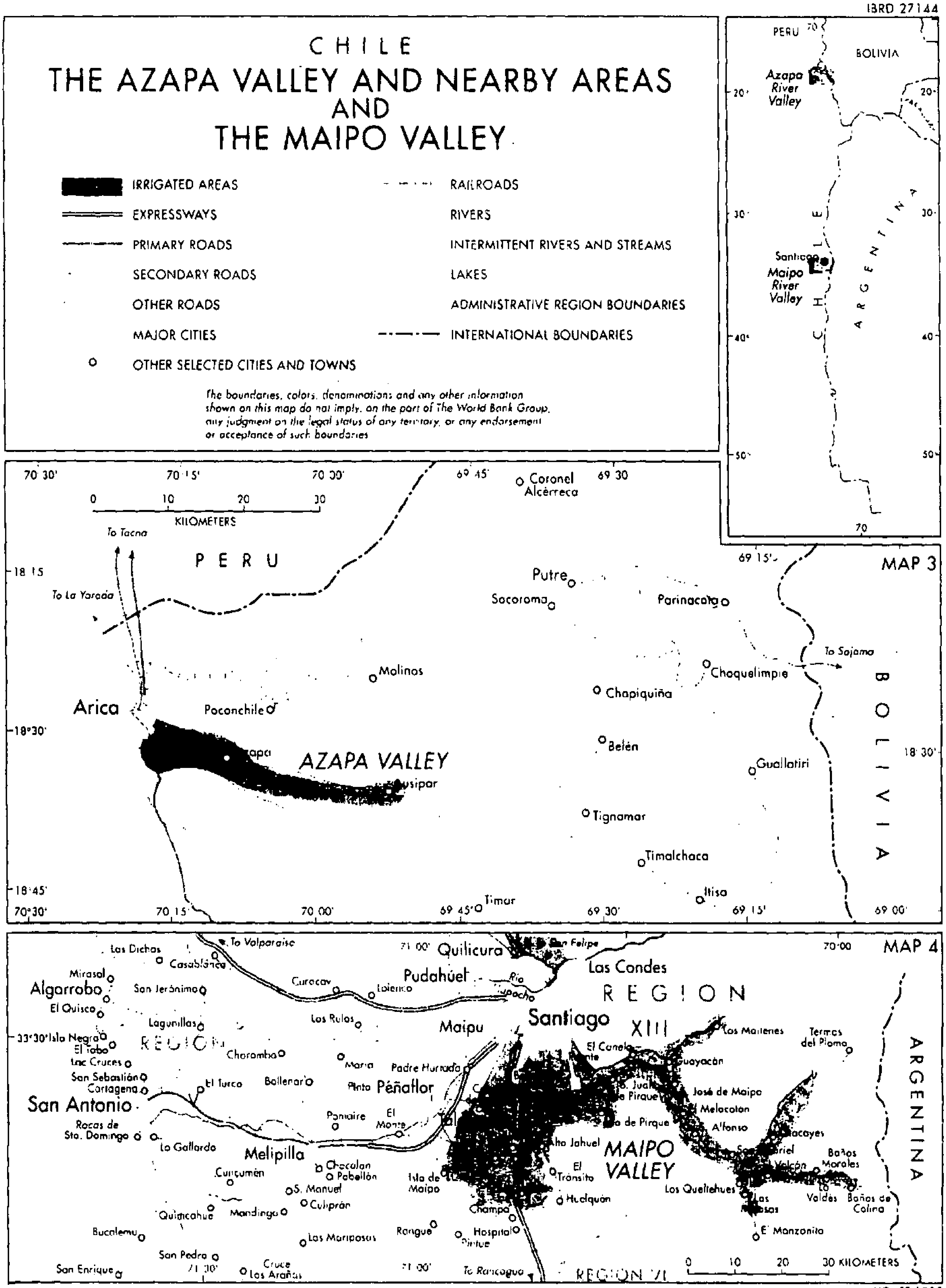
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CHILE
THE AZAPA VALLEY AND NEARBY AREAS AND THE MAIPO VALLEY
IRRIGATED AREAS
EXPRESSWAYS
PRIMARY ROADS
SECONDARY ROADS
OTHER ROADS
MAJOR CITIES
OTHER SELECTED CITIES AND TOWNS
RAILROADS
RIVERS
INTERMITTENT RIVERS AND STREAMS
LAKES
ADMINISTRATIVE REGION BOUNDARIES
INTERNATIONAL BOUNDARIES
The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
PERU
BOLIVIA
Azapa River Valley
CHILE
ARGENTINA
Santiago
Maipo River Valley
MAP 3
KILOMETERS
To Tacna
To La Yarada
PERU
Coronel Alcérreca
Putre
Socoroma
Parinacota
To Sajama
Molinos
Choquelimpie
Chapiquiña
Arica
Poconchile
Belén
AZAPA VALLEY
Guallatiri
BOLIVIA
Tignamar
Timalchaca
Itisa
Timar
MAP 4
To Valparaíso
Quilicura
San Felipe
Las Dichas
Casablanca
Mirasol
Curacaví
Pudahuel
Las Condes
Algarrobo
San Jerónimo
Lo Prado
REGION XIII
El Quisco
Los Rulos
Santiago
Lagunillas
Maipú
Los Maitenes
Termas del Plomo
Isla Negra
El Tabo
Chorombo
Las Cruces
María Pinto
Padre Hurtado
San Sebastián
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Melipilla
MAIPO VALLEY
Baños Morales
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Isla de Maipo
El Tránsito
Curçumén
S. Manuel
Los Queltehues
Quincahue
Mandinga
Culiprán
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Valdés
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Rangue
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Cruce Los Arañas
To Rancagua
REGION VI
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0 10 20 30 KILOMETERS
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