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REFORMING WATER ALLOCATION POLICY THROUGH MARKETS IN TRADABLE WATER RIGHTS: LESSONS FROM CHILE, MEXICO, AND CALIFORNIA*

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ABSTRACT

Increasing water scarcity, rising costs of irrigation subsidies, and general economic liberalization are creating strong incentives for comprehensive water reform with establishment of tradable water rights and the development of markets in these rights. Experiences in Chile, Mexico, and California indicate that water allocation through markets in tradable water rights offers a viable approach to improving the efficiency of water allocation, and should receive serious consideration from developing country policy makers. Laws establishing tradable rights should be simple and comprehensive, should clearly define the characteristics of water rights and the conditions and regulations governing the trade of water rights; should establish and implement water rights registers; delineate the roles of the government, institutions, and individuals involved in water allocation and the ways of solving conflicts between them; and provide cost-effective protection against negative third party and environmental effects which can arise from water trades.

1. INTRODUCTION

Water policy in developing countries faces a number of serious challenges, foremost among them the need to increase the efficiency of water use in agricultural, urban, and industrial use. Irrigated area accounts for over two-thirds of world rice and wheat production, so growth in irrigated output per unit of land and water is essential. Improved efficiency in

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agricultural water use should permit growth to be maintained and, at the same time reallocate water from agriculture to urban and industrial uses. New sources of water are increasingly expensive to exploit. The only source of water savings of the necessary magnitude to meet growing demand is irrigated agriculture, which generally accounts for at least 80 percent of consumptive use of water in developing countries. The improved efficiency in agricultural use, to truly contribute to reducing water scarcity, should be accompanied by improved efficiency in urban and industrial use. It does not make sense to make efforts to improve agricultural water use efficiency, only to squander these savings to inefficient urban water systems.

A second major challenge is to sustain the land and water resource base in the face of mounting pressure to degrade these resources through waterlogging, salinization, groundwater mining, and water pollution. The third challenge is to reduce the enormous financial resources used by governments in building new water infrastructure and in water operations and management. Finally, an overarching challenge is to increase the flexibility and responsiveness of resource allocation. Developing countries in much of the world are rapidly liberalizing their economies, putting a premium on flexible response in allocation of water, land and other resources in response to changing economic opportunities.

This paper explores the potentials and constraints for the development of markets in tradable water rights to help meet these challenges. Tradable water rights are rights to use water that can be transferred all or in part, separately from the transfer of land. While tradable water rights should be permanent, or very long term, to ensure the security of the right, the transfer of water rights need not be permanent: water rights can be leased for a season, a year, or many years. The paper uses a comparative case study approach, drawing lessons for developing countries from the experiences with tradable water rights in California, Chile, and Mexico. The comparison of these countries provides important insights because Chile has had nearly 20 years of experience with markets in tradable water rights, following a fundamental restructuring of water laws; Mexico is in the early stages of implementing a comprehensive legal reform establishing tradable water rights; while California has undertaken more gradual reforms to increasing the flexibility of water marketing and trading within a long-established water law tradition that is in some ways inimical to water markets.

The analysis draws on detailed case studies (Gazmuri and Rosegrant, 1994; Rosegrant and Gazmuri, 1994; and Rosegrant, 1994). The primary focus of the paper is on the laws, institutions, and policies that condition the success of allocating water through markets in tradable water rights. The study relies largely on interviews with participants and observers of water policy in the study areas, analysis of secondary data, and synthesis of existing literature. A limited amount of primary data collection was also undertaken.

The paper outlines the potential benefits from, and constraints to establishment of tradable water rights; examines the underlying incentives which induce institutional and legal reform to establish tradable water rights; assesses policies for successful implementation of markets in tradable water rights and actual impacts of water market allocation in practice; and concludes with lessons for the potential of markets in tradable water rights as a key component of water allocation policy in developing countries.

2. Markets in Tradable Water Rights: Benefits and Constraints

For most commodities and inputs, allocation by means of markets has been the favored solution of economists. Economic theory shows that market allocation will be

efficient, given well-defined and nonattenuated initial property rights and zero transactions costs. Well-defined and nonattenuated property rights are completely specified, exclusive, transferable, and enforceable (Coase, 1960).

Obviously, the assumption of zero transactions costs does not hold true in markets for water rights, where information, conveyance, and enforcement costs may be higher than in most input markets. However, even in a world with transactions costs, markets in tradable water rights may lead to considerable efficiency gains and other benefits. Tradable water rights empower water users by requiring their consent to any reallocation of water and compensation for any water transferred. Well-defined water rights improve the bargaining power of farmers and farmer groups relative to the public irrigation bureaucracy. With secure rights, the water users can invest in water-saving technology knowing that they will benefit by selling or otherwise using the water saved. Farmers also have an incentive to shift to water-conserving crops. The combination of secure water and land rights can foster urgently needed private domestic and foreign investment in agriculture.

Marketable rights to water can induce water users to consider the full opportunity cost of water, including its value in alternative uses, thus providing incentives to efficiently use water and to gain additional income through the sale of saved water, and to take account of the costs imposed by their water use on other farmers, reducing the pressure to degrade resources. A simple example is the farmer at the head of the canal who overuses water, thereby waterlogging other farmers through excess seepage and percolation. If he can trade the excess water instead, he would conserve resources.

Compared to the often-recommended volumetric pricing of irrigation water, the rights-based approach is also more acceptable to farmers. Traditional water rights are already capitalized into the value of land. Imposition of volumetric pricing are seen by farmers as expropriation of these traditional water rights, which creates capital losses in established irrigated farms. Establishment of transferable water rights instead formalizes existing rights to water, increasing the capital value of land.

Market allocation of water, and its logical corollary, the requirement for private financing of water infrastructure and water management and operation, work in favor of the low income population through removal of massive capital and operating subsidies which usually favor better-off producers and urban consumers. Market-based allocation frees-up enormous budgetary resources which can be used for targeted subsidies to the poorest sectors of the population.

Finally, allocation of water through tradable rights provides maximum flexibility in responding to changes in crop prices and water values as demand patterns and comparative advantage change and diversification of cropping proceeds. The market-based system is more responsive than centralized allocation of water.

Despite these potential benefits, the use of market-based water allocation mechanisms has been limited by concerns over the possible political, institutional and technological constraints to managing such a system, and possible inequities arising from market-based allocations. Laws, institutions, and physical water systems must be reformed or developed to equitably assign water rights, to deal with variability of water supply, to protect against damage to others or to the environment arising from water transfers, and to resolve conflicts. Despite these apparently formidable challenges, reforms have been implemented in California, Chile, and Mexico to develop markets in tradable water rights. The next section explores the reasons behind these reforms.

3. Incentives for Markets in Tradable Water Rights

The forces behind reform of water allocation to create or expand markets in tradable water rights in California, Chile, and Mexico derive from three related developments: (1) the increasing economic value of water due to scarcity caused by rapid growth in demand for delivered water, depletion of new supply sources, and competition for water among agricultural, industrial, urban, and instream uses; (2) rising budgetary costs of maintaining centralized control of irrigation and urban water delivery due to increasingly expensive and highly subsidized capital development and operations and maintenance of water systems; and (3) broad economic liberalization, which increases the economic cost of maintaining inflexible and inefficient water allocation systems which cannot respond rapidly to changing incentives and comparative advantages.

The gradual reform of California water law to permit greater flexibility in water trading has been driven by the first two factors. Rapidly growing urban and environmental demand for water, the high economic and environmental costs of developing new water supplies, public rejection of infrastructure options such as the peripheral canal linking the water-surplus north with the increasingly water-scarce south, and serious droughts in recent years have induced policy changes to facilitate water trading. In 1982, California adopted a statewide policy of encouraging voluntary water transfers between agencies throughout the state. This policy was based on the assessment that there are fewer environmental impacts associated with transfers than with construction of conventional projects, and although difficult to implement, transfers can be implemented more quickly and usually at less cost than construction of additional facilities. Since then, a number of laws have been passed to facilitate the sale, lease, exchange, or transfer of water and to ensure that water conveyance facilities are available for use in transferring water (Department of Water Resources [DWR], 1992).

Specific innovations in recent years have included Water Code reform to permit the transfers of salvaged or conserved water previously lost to beneficial use, to permit the purchase of water for instream flow as a beneficial use, and to allocate available conveyance capacity in state water delivery systems to water transfers; the implementation of the State Emergency Drought Water Banks in 1991, 1992, and 1994, which have demonstrated the ability to quickly broker large-scale market transfers; market-like conservation measures such as the deal in which the Metropolitan Water District of Southern California (MWD) paid for the lining of canals and other physical and management improvements in the Imperial Irrigation District (IID) in exchange for the most of the water conserved; liberalization of rules for water trading in the huge federal Central Valley Project; and the completion of general environmental impact reports on water transfers which will streamline future analysis of individual transfer requests, reducing the costs of verification and approval.

Water policy reform in Chile and Mexico was partly influenced by growing water scarcity-induced increases in the value of water, but reform was more directly driven by broad economic reform and budgetary cost considerations. Although economic liberalization is neither a necessary, nor a sufficient condition for development of water markets, when a country begins the process of economic reform, moving toward liberalized trade and a market-based economy, the establishment of clear and secure land and water property rights and market allocation of both resources are necessary to generate the full benefits of overall economic reform. With a liberalized economy, if land and water rights are not clear and transferable, the agricultural sector has limited flexibility to cope with the changes in demand and prices on international markets. General economic liberalization increases the costs of

maintaining centralized water allocation policies, thereby increasing the incentives to shift to market-oriented water policies.

In the early 1970s, Chile had become a highly centralized and regulated socialist economy, following a decade of increasingly socialist policy changes, which included the expropriation of land and water rights. In addition to regulating the economy and fixing the most important prices, the state owned practically all of the productive system of both goods and services.

Immediately after the change of government in 1973, the new government shifted towards a market-oriented social and economic policy, with complete economic liberalization and open trade. The shift to a market-oriented open trade policy placed a premium on efficient and flexible allocation of water, land, and other resources in the agricultural sector in response to changing economic incentives and opportunities. The fundamental policy reforms to facilitate efficiency and flexibility in resource allocation in agriculture were the redistribution of land and water resources to the private sector under the Agrarian Reform; the definition of clear and well-defined land and water property rights; market allocation of both of these resources; and the drastic reduction of general water subsidies to both agricultural and urban water users.

In the early 1990s Mexico began its own process of economic liberalization, shifting from a state centralized, highly regulated system, to a market-oriented one. In accordance with this new economic and social approach, the government proceeded to reform Article 27 of the Constitution, which had communalized much of land and water rights in agriculture, and passed a new Agrarian Law. Under the new agrarian policy farmers become independent from the state in their production and commercial decisions. Full and secure property rights to land were established, both in the communal (*ejidal*) sector and in the private sector. Limits to the size of farms were essentially abolished, as was the prohibition on foreign land ownership in Mexico.

Economic reforms meant that after a transition period with direct subsidies to farmers, farmers would have to be able to produce at internationally competitive prices without subsidies of any kind, except for the extremely poor, non-commercial farmers. It was recognized during the debate over economic reform that, under the new economic system, retention of the existing water laws could severely limit the benefits of freeing up land markets and liberalizing the economy, and would continue to drain the government of budgetary resources because of the huge financial costs and inefficiency in construction and management of infrastructure, a costly central administration, and poor collection of O&M costs in irrigation and tariffs in urban water use. At the time of passage of the new water law, operations and maintenance cost of government-owned water and irrigation systems accounted for 0.5 percent of gross national product.

The prevailing water law, with centralized water allocation, was also considered an important obstacle to successful implementation of the new liberalized agricultural policy. With individual farmers making the cropping decisions, bureaucratically-set water allocation would not match the water requirements of farmer-determined cropping systems. Therefore, along with general economic reform, Mexico began the process of implementing fundamental changes in its water policy with respect to water rights, water management, and allocation of water, with passage of a new Water Law in December 1992, which, among other important features described below, created tradable water rights, and initiated the process of turning over the operation and maintenance of irrigation systems to farmers.

The case studies show that factors which increase the value of water, that boost the cost of government water management, or that increase the costs of maintaining relatively inflexible water allocation mechanisms provide strong incentives for governments to increase

the efficiency of water allocation through reforms to establish tradable water rights and market mechanisms for water allocation. Other countries which are experiencing increasing water scarcity and budget drains for water development and management and/or undertaking the process of economic liberalization will face similar strong pressures to reform water allocation processes to create tradable water rights and market-based water allocation. It is obviously impossible based on these case studies to predict at what point these developments become serious enough to induce any given country to move toward market-oriented reform. Shifting from administrative allocation of water rights to market allocation implies a very important, and likely irreversible, political decision. On the one hand it means shifting significant amounts of power from the government to the water users; and, on the other, it can mean relieving the government of enormous expenses in investments in water infrastructure and operations and maintenance costs that are also shifted to the final users.

The degree to which incentives to establish market-oriented water allocation are translated into actual reform is also conditioned by the existing legal and political structures and processes governing the use of water resources. The gradual approach to reform undertaken in California has been largely the result of long-standing water law, developed under different historical and economic conditions, which in many ways constrains water trading; and the interaction of powerful and often competing interest groups with high stakes in water. The role of existing water law in slowing the growth of water trading in California will be discussed in detail below. The interplay of interest groups has been equally important in determining the pace of liberalization of water trading. Urban interests have long favored maximum flexibility in making market transfers, since growing demand for water is primarily in the urban sector, and water transfers would go mainly from agricultural to urban uses.

Despite considerable dissent from farmers who see the potential benefits from water trading, agricultural and rural interests have mainly opposed rapid liberalization of water trading, fearing devastating economic losses following massive transfers of water to cities. The response of rice farmers in the Sacramento Valley to the State Water Bank is indicative of the rural/agricultural position. Rice farmers were subject to pressure from the local community and rice farmer cooperatives not to participate in the water bank. The rice growing regions opposed water sales for several reasons. Cooperatively owned rice processing organizations feared loss of volume, while some growers wanted a higher water price. In addition to these economic reasons, regional political leaders wanted to assert the independence of the area of origin of much of the state's water (Gardner and Warner, 1994).

Environmental interests are ambivalent on the issue of increasing the flexibility of water transfers. While water trading is seen as a partial solution to meeting increasing urban demands without building damaging new water projects, many water transfers have raised serious concerns that the temperature and flow fluctuations caused by the water transfers and releases will be harmful to fish and wildlife, particularly salmon eggs and fry. The political dynamics arising from the interplay of these competing interest groups, together with the existing legal structure (and an extraordinarily difficult hydrological and physical environment, to be described below) have dictated an incremental approach to increased water trading in California.

The political conditions for establishment of markets in tradable water rights in Chile and Mexico, which are more representative of other developing countries, are also far more conducive to comprehensive reform than in the California case. In Chile and Mexico, the main stakeholders in water, the farmers, did not have a strong interest in the status quo; to the contrary, the existing system of water law and management gave farmers only precarious rights to water and very little say in the distribution and management of the

resource. As will be shown in more detail below, comprehensive legal reform to establish tradable water rights was seen as a major benefit by farmers, and has received strong political support by farmers. Support for comprehensive reform has also been strong in the broader government ministries dealing with agricultural, finance, and economic planning, which have had to cope with the adverse economic and fiscal consequences of the existing water policies. The main proponents of a slower or more limited reform of water rights have instead been the bureaucracies which have directly controlled water management.

In Mexico, although there was broad agreement within the government on the need for well-defined, secure tradable water rights, there were differences in preferences on the appropriate degree of regulation of water markets and on the speed of turnover of irrigation systems to users. The Ministry of Agriculture was in favor of a rapid turnover of the administration of water and water infrastructure, as well as financial responsibility, to newly created independent water users associations (WUAs), while the Comision Nacional del Agua (which builds and manages water infrastructure) favored a period of co-administration between the water authority and the users, especially in respect to dams and river basins. The law that was passed in December 1992 reflected a compromise of these positions.

In Chile, the only serious attempt to modify the new Water Code was introduced in legislation developed at the Ministry of Public Works. The legislation, sent to parliament in December 1992, generated a heated public discussion among policy makers and water users. The most important proposals included: (a) forfeiture of water rights if not used for 5 years from the time of effective use established in the grant; (b) requirement that prospective grantees should demonstrate need for the water 3; (c) provision of more authority to the central government in conflicts related to water pollution and third party effects; (d) creation of Administrative Associations of River Basins (*Administradoras de Cuencas Hidrográficas*), including both private and public entities; and (e) assignment of rights to specific use (agricultural, industrial, or household) in the most arid regions of the country. A change in use would then require government approval.

All of these provisions reduce the security of existing water rights, and increase the administrative discretion of the government in water allocation. Water users associations and farmers associations therefore strongly opposed the legislation. The bill has been frozen out of the legislative agenda by parliament, and the government has not reintroduced it.

It is clear that the different degrees of willingness of government countries to transfer economic power to the people, different government perceptions of the role of the state in managing key resources, and the political interests and strengths of the main stakeholders in water will be important factors in determining whether and to what extent tradable water rights and market allocation will be established. However, the politics of water in Chile and Mexico, which appear to representative of many developing countries, have proven to be conducive to comprehensive reform. With trends in much of the developing world pointing toward growing water scarcity, rapidly increasing fiscal costs of maintaining the existing highly subsidized centralized management of water, and increasing general economic liberalization, all of which create pressures for reform of water allocation policy, it is important to understand how markets in tradable water rights can be established and managed.

4. Policies for Successful Implementation of Tradable Water Rights

In general, reform of water allocation mechanisms to implement markets in tradable water rights can either be part of comprehensive reform aimed at improving efficiency of the

entire water distribution system as in Chile and Mexico, or can be incremental, as shown by the California case, which has gradually increased the flexibility of water trading within the context of a legal code which is in many ways antithetical to trading of water rights.

Outside of the often highly effective endogenously managed irrigation systems which are found in small numbers throughout the world, water rights in developing countries are typically poorly defined and precarious. Comprehensive reform of water law is therefore the most effective means of moving toward markets in tradable water rights within the developing country context. To form the basis for allocation of water through tradable rights, the law should be simple and comprehensive, should clearly define the characteristics of water rights and the conditions and regulations governing the trade of water rights; establish and implement water rights registers; delineate the roles of the government, institutions, and individuals involved in water allocation and the ways of solving conflicts between them; and provide protection against negative third party and environmental effects which can arise from water trades.

Creation of tradable water rights can be highly beneficial even if public ownership and management of water supply and delivery systems is maintained. However, a logical (and in the longer run probably compelling) extension of comprehensive reform, which may significantly increase the benefits of establishment of tradable water rights, is the privatization of some or all of the physical infrastructure. If this step is taken, the water law should also set the ground rules for turnover of existing irrigation system infrastructure to water users, for the approval and financing of new infrastructure construction, and for the privatization and regulation of urban water and sewage services. These reforms were handled comprehensively in the Chilean water law reform, and to a significant extent in the Mexican reform.

Within the context of reform to create markets in tradable water rights, whether wholesale or incremental, a number of complex implementation issues arise. The next several sections explore the lessons that can be learned from the case studies on appropriate policies for implementing effective markets in tradable property rights. Important issues that arise include the method for initial allocation of water rights, definition of rights as prior or proportional, consumptive use and the treatment of return flows in water trading, negative indirect economic effects, protection of the environment, the role of water user associations, infrastructural requirements, and the role of public and private institutions. A key theme will reappear throughout this discussion: the importance of maintaining fairness in the implementation of water rights and the protection of the interests of all participants in the market allocation of water, while at the same time maintaining low enough transaction costs to make water markets operate efficiently.

Transaction Costs

Transaction costs arise whether water allocation is determined through administrative discretion or through water markets, and include (a) the cost of identifying profitable opportunities for transferring water, (b) the costs of negotiating or administratively deciding on the water transfer, (c) the cost of monitoring possible third party effects and other externalities, (d) the infrastructure cost of actually conveying the water and monitoring the transfers, and (e) the infrastructure and institutional cost of monitoring, mitigating, or eliminating possible third party effects and externalities.

Under administrative allocation, a public or quasi-public water authority (e.g., a river basin commission, or a national or regional water authority) would identify water demands or alternative uses and simply reallocate existing water allocations or rights to

higher-valued uses. Since the losers will undoubtedly protest, the authority will have to negotiate with the users and find some way of compensating the losers. Administrative allocation also may be subject to political pressures, and is often subject to high costs of inefficiency and private rent seeking by those managing the system, who do not have the same incentive to minimize the total cost of water transfer as a buyer would,

Markets in tradable water rights, on the other hand, use the price response of users to reallocate water. Users have an incentive to increase their water use efficiency, and low-valued uses will give up water to higher valued uses in a decentralized decision process involving the individual users. With tradable rights, since buyers will bear the costs of conveyance and mitigation, they will attempt to find those trades which minimize the total of purchase price, conveyance, and mitigation costs. Water markets thus have some important possible advantages in minimizing transactions costs, but the ways in which markets are organized and regulated have a major impact on transaction costs. Excessive regulation which creates high transaction costs can greatly reduce the benefits of water trading, while inadequate regulation can impose unacceptable costs on third parties or the environment. The ways in which water law, institutions, and technology can balance the protection of interested parties in the water market allocation process with the transaction costs of this process are explored in several sections below.

Fairness in initial allocation of water rights

The first condition for success in developing tradable water rights is agreement on the rules of the game, beginning with the perception of fairness in the initial assignments of water rights. The fairness objective seems to have been met in Chile and Mexico, by basing the initial allocation on historical water use, combined (in Chile) with redistribution of concentrated rights holdings. The assignment of rights is formalized through registration of the rights in Public Registries in each country. In Mexico, the fundamental basis for initial allocation of water rights is the existing informal or formal water right already held; previous water use can be established by certification from an Irrigation District or *ejido* administrator, or by testimony of neighbors as to the individual's land and water rights under previous law. Although granting of concessions is at an early stage, discussions with farmers and officials do not indicate much concern that the initial allocation process will be inequitable. Titling of land rights in the same areas as water rights is well underway. The prior or simultaneous completion of land titling facilitates the allocation of water rights. In Chile, the establishment of tradable water rights beginning in 1975 was linked to the re-privatization of land that had been collectivized in 1966. Land and the proportional right to water historically used on this land was returned 40 percent to former landowners and 60 percent to former workers on the lands. After the turmoil caused by expropriation of land and water in the 1960s, the establishment of tradable water rights and redistribution of a large portion of these water rights to former landless laborers was seen as an substantial improvement in equity. In California, the equity of initial assignment of rights has not been a major issue in the context of increasing the flexibility of water. Available water rights have long since been fully appropriated. However, the fairness of reallocation of rights through market or other mechanisms arises in an number of contexts below.

Prior vs. proportional water rights

A key distinction between water rights in California on the one hand and Chile and Mexico on the other is that the former defines rights on a priority basis, while the latter two

effectively define the water right as proportional to streamflow or canal flow. In Mexico, water rights are technically specified in volumetric terms, rather than in proportion to streamflow; and the irrigation districts and water user associations (WUAs) are charged with developing procedures to allocate surplus and deficit water within their boundaries. Indications are that surpluses and deficits will simply be allocated proportionally across all existing rights, so that, for example if streamflow is 20 percent below normal, each rights holder will receive 20 percent less water. This procedure effectively converts the volumetric right to a proportion of streamflow right. In Chile, water rights are proportional rights (shares) over a variable flow or quantity; deeds stipulate that an owner has the right to a certain number of shares at a certain location. These rights are expressed in volume by unit of time (liters per second or cubic meters per year or month) and are proportional if supply is insufficient.

In California, both riparian rights and appropriative rights to water exist, but tradable water comes exclusively from water held under appropriative rights doctrine. The appropriative rights doctrine limits the flexibility of reallocating water to the most productive purposes in response to shortages induced by drought. The "first in time, first in right" principle in the appropriative rights system ensures that, when shortages occur, senior rights holders, who established their rights before junior appropriators, receive first priority to available water, whether or not they are using the water for high-valued purposes. Because these priorities are not based on economic returns, but on chronological time of establishment of the water right, considerable inefficiencies can occur due to deprivation of higher values uses of water.

Water shortages in federal water projects in California are in theory handled differently from privately acquired appropriative rights, in that water users within a reclamation district share the effects of drought. Thus even the most senior irrigator in a water district may have to reduce water usage by the same percentage as every other user in the district. However, often the burden is deliberately shared unequally. In California's San Joaquin Valley, for example, most water districts allocate surface water on the basis of acreage served, and during shortages, many give preference to lands growing permanent crops (Reisner and Bates, 1990). Thus, under either state or federal water rights, top-down rationing of water is often invoked during droughts. The inability to get water where it is most needed during shortages is a major limitation of the prior rights system.

The choice as to which type of rights works best to facilitate water markets must balance out the advantages and disadvantages of each of the two approaches (Howe, Schurmeier, and Shaw, 1986). The priority rights system allows different degrees of water supply reliability to be purchased, but the heterogeneous nature of the rights makes it difficult to organize the market. With proportional rights, some inefficiencies may be introduced because users must hold more shares to reach any given level of assurance of water supply due to the variable supply of water, but the homogeneity of proportional rights makes it much easier to create markets. The proportional rights system is also more flexible and equitable in allocating water deficits than a prior rights approach. The equal sharing of shortages is an important advantage. Overall, the advantages of the proportional rights approach in facilitating market creation and in equitable allocation of deficits outweigh the possible market inefficiencies from the need to hold extra shares (see also Frederick, 1985).

The proportional rights system has worked well in water trading in Chile, despite the variability in actual water produced by a given share right. Water users readily adjust their purchase or lease decisions depending on the probable yield of a water right at any particular time. *Short-term cash rentals, or water swaps, are quiet usual betwen the users of the Limarí River, in the north, and in the Central Zone, where some crops require water until*

December (p.e. wheat and barley) and others need it until April (p.e.sugarbeet and corn). A typical case of a short-term cash rental would be a farmer who uses 3 shares of 15 l/sec to irrigate 30 ha of high yield wheat from October to December. He crops his wheat in late December and rents the water from January until April, to a 30 ha sugarbeet producer, who also uses his own 3 shares for irrigation. This last farmer will be willing to rent water because each share will actually be delivering only about 7-8 l/sec during the low flow summer period. With the rental of water, the sugarbeet farmer completes the 45 l/sec he needs. If the water market was not available, the wheat farmer would apply his water to a lower income purpose, such as irrigating the wheat-cropped land for grazing. On the other hand, the sugarbeet farmer would have to cultivate only the 15 ha he can irrigate with his summer availability of water. With the rental options, both farmers win.

Consumptive use and return flows

A second key distinction between water rights in California and in Chile and Mexico lies in the definition of the tradable portion of the water right. In California, the transferable portion of the appropriative water right is limited to consumptive use, with protection of third-party rights to return flows. This system protects prior rights to return flows, but, depending on the implementing regulations, significantly increases the transaction costs of water trading, because of the difficulty in measuring consumptive use and return flows.

California's system for determining the tradable fraction of appropriative water rights in terms of consumptive use imposes a strong burden of proof on the prospective water seller for determination of how much water is tradable. Six sources of tradable water are available: fallowing (not irrigating crops), shifting to lower water-using crops, substitution of groundwater for surface irrigation water, direct delivery of groundwater, conserved water, and water from reservoir storage. In regulating each of these types of transfer, the Department of Water Resources distinguishes between new water, which is water previously not available to the system; real water, which is water available for transfer that is not derived at the expense of other water rights holders; and paper water, which is water proposed for sale that does not create an actual increase in system supply. Strict requirements are placed on each category for identifying the new or real water available for transfer. The level of proof required can be illustrated for the case of fallowing.

Water saved by withholding irrigation water from the field for an entire irrigation season can be transferred to another use. Although this concept appears straightforward, determination of tradable water requires verification of farmer intentions, adequacy of water supply, and computation of consumptive use. To determine farmer cropping intentions, the DWR uses long-term crop and water records, and personal knowledge of extension agents and other experts. Determination of availability of water requires information about the rights and contracts pertaining to the fallowed farm, together with estimation of actual availability of irrigation water during the period of transfer. For short term transfers, this is relatively easy, but for long term transfers, there is considerable uncertainty, since the future availability can vary due to droughts, operational restrictions, or legal and policy changes affecting future contracts.

The final step in determining tradable water is computation of consumptive use. In California, the concept of "consumptive use" has evolved over time, and there is still some uncertainty in interpretation. However, the generally accepted definition is now actual crop evapotranspiration of the crops plus percolation of water that is lost to further use. Under the 1992 CVPIA water available for trade includes "water that would have been

consumptively used" and water "irretrievably lost to beneficial use." Thus, water which would otherwise percolate to the degraded groundwater in parts of the San Joaquin Valley would be tradable, but water draining to wetlands or used by vegetation that provides significant wildlife habitat would not be tradable (DWR, December 1993).

Chile and Mexico have in essence followed an alternative model developed in the Northern Colorado Water Conservancy District (NCWCD), where rights are proportional to streamflow and rights to return flow are retained by the district. Return flows are made available to water users at no charge, but no rights are established to these flows. Changes in patterns of return flows due to trades are therefore not actionable. By defining away third-party rights to return flows, the NCWCD has greatly reduced transactions costs to trades, resulting in a very active water market (Howe, Schurmeier, and Shaw, 1986; Cummings and Nercessiantz, 1992).

Chile and Mexico have followed the NCWCD model by defining tradable rights as full diversion rights which are proportional to stream or canal flow. Rights to return flow do not exist. In Chile, return flows to neighboring areas may be used by the recipients without the need to establish a right of use. However, use of this water is contingent upon the flow of the main waterways and usage rates of the rights holder. There is no obligation to supply return flows and such flows are thus not permanent. In Mexico, the initial concession of water rights is based on the normal previous consumption of water by the individual or group. However the law makes clear that this "consumption" is not the "consumptive use" rights with obligation to maintain a specific amount of return flow which are common in the western U. S., but rather is the full diversion right.

The question of which system is more appropriate for developing countries raises complex issues. Potential water transfers that are not made because of restrictive regulations can be very costly due to the gains from trade foregone. The transactions costs of enforcing the consumptive rights approach can be very high, reducing the number of trades possible; on the other hand, the consumptive rights approach more clearly protects third parties against adverse impacts from water trades. The decision on which approach to use is ultimately an empirical question. If the lost benefits from failure to undertake water trades due to the high transactions costs of enforcing return flows are greater than the net cost of adverse impacts resulting from lost return flows, then the full diversion right approach is preferable. To the extent that real losses do occur from loss of return flows, innovative methods could be used to compensate those who are hurt by loss of return flows. Reforms that could move in this direction would be to provide financial compensation for losses out of the proceeds of the trade, or reservation of a portion of water rights to the water user associations, water districts or other water suppliers to be allocated to compensate for actual damages due to reduction in return flow if the simpler procedures fail in some cases.

Under developing country conditions, the Chile and Mexico approach of tradable shares with no rights to return flows is preferable as a general principle; enforcement of consumptive rights following the California model would be extraordinarily costly and would likely prevent the development of markets. Nevertheless, within many countries, hydrological conditions in some river basins, where return flows are very large and traditional rights to these flows exist, will make additional protection of return flows necessary.

In Chile, there are two important river basins where additional protection to return flows has been employed: the Aconcagua River, in an area with a large proportion of high-valued crops; and the Elqui river, a small but significant river because it is located in the desert zone. These two rivers irrigate very narrow valleys, and return flows are large. The reduction or elimination of return flows, due to sales or efficiency gains, may affect drastically the total flow of a section of the river. The Elqui River Water Users Association

has dealt with this problem by limiting trades within upstream areas to farmer-to-farmer transactions (to retain all return flows within the basin), with agriculture-urban transactions authorized only in the downstream area.

Where return flows are highly significant, other methods could also be tested to protect these flows while keeping transactions costs low. New Mexico uses simpler and less costly procedures than California. The State Engineer's Office determines transferable water quantities utilizing standard formulae together with historical and secondary data. Reliance on standard transferable quantities for specific regions, soils and climates reduces the transactions costs incurred by applicants for hydrologic and engineering experts, saves staff time of the water agencies, and creates more certainty in the transfer process (Colby, 1988).

An even simpler procedure would be to create a uniform presumption regarding consumptive use and return flows, which eliminates the need to determine consumptive use on a case-by-case basis. In Wyoming, the statute which authorizes temporary water transfers creates a presumption that 50 percent of diverted water is allocated to return flows, with the remainder considered to be the tradable quantity. Although attempts to rebut the presumption could be made, these would likely be infrequent if the presumption is a reasonable approximation. If, as is likely, a uniform state-wide presumption is not feasible due to different agroclimatic conditions, regional presumptions could be established (Gould, 1989).

An approach worth assessing in practice in river basins where return flows are significant would be a combination of the Elqui and New Mexico methods. A determination could be first made of areas where return flow restrictions were not necessary, because return flows are lost to beneficial use. In these areas, such as the downstream area of the Elqui, any trades could be made of the fully diverted share. In all other sections of the river basin, intersectoral water trades (which would affect beneficial use of return flows) would be subject to a presumptive return flow allowance. In evaluating any of these alternatives to protect return flows where it is empirically necessary, the key is to keep the transaction costs low while limiting return flow presumptions to the maximum that are genuinely produced, so as to preserve incentives for conservation and increase the gains from efficient market transfers of water.

Furthermore there is a quiet simple solution that can solve mostly any problem with return flows and intersectorial water trade. Let's suppose farmers are named from A to Z, upstream to downstream. Farmer C sells "x" lts/sec to the water company and to avoid third party effect, the UA transfers the amount of water "trough" the different farmers. They will transfer C's "x" lts. to D, D transfers them to E, E to F, and so on until they arrived to Z who will transfer them to the Water Company. The transaction will meet it's purpose: C sells "x" lts. per second that, finally, go to the buyer; but delivered trough Z . There is no "return flow third party effect". Really it only means more legal paper work and, in some cases, small modification in the *bocatomas* financed buy the buyer.

Protection against negative indirect economic effects

Water transfers can negatively affect business activities, local government fiscal capacity and the quality of public services in areas from which water is being transferred because of the reduction in irrigated area or production and with associated reductions in agriculturally-linked economic activities in the area of origin and in the property tax base. In addition, permanent transfer of water rights may limit future economic development in the area of origin. If, in the future, economic conditions make expanded irrigated agriculture, new industrial activities, or residential development economically attractive, then water may not be available locally to pursue these opportunities. Although area-of-origin effects are of

understandable concern to area residents, analysis suggests that the direct and indirect economic impacts of water transfers on the area of origin generally are small from a regional or state perspective. Indirect economic effects from the water transfers using the 1991 California State Emergency Drought Water Bank were small. Farmers who sold water to the Bank reduced farm operating costs by $17.7 million, or 11 percent, and crop sales by $77.1 million, or 20 percent. These reductions adversely affected the suppliers of farm inputs and the handlers and processors of farm outputs, but the impacts were not large when compared to the agricultural economy in the selling region. The study estimated that operating costs, crop sales, and agribusiness revenues dropped 2 to 3 percent in selling counties because of the Bank (Dixon, Moore, and Schechter, 1993).

Despite these relatively small impacts, in California, both State and Federal law contain projections against general economic impacts, and more have been proposed. During the years when major water projects were being developed, a variety of area-of-origin legislation was enacted to protect local Northern California supplies from being depleted as a result of the projects. For example, County of Origin Statutes provide for the reservation of water supplies for counties in which the water originates when, in the judgment of the State Water Resources Control Board, water transfers will deprive the county of water necessary for its present and future development. State law also prohibits the use of public agency facilities to transfer water unless a finding is made of no unreasonable impact on the overall economy of the county from which the water is diverted. Further restrictions on aggregate amounts of water which can be transferred are embodied in recently enacted provisions requiring that water suppliers limit the amount of transferrable water made available by fallowing to 20 percent of the water that would have been applied or stored by the supplier.

Explicit protection for specific categories of indirect adverse impacts are not included in the Chilean and Mexican water laws. However both laws provide for strong protection of third party rights arising from trades. In addition to approval authority by local WUA, third-parties who could be damaged by a trade are further protected through prohibition of damaging transfers or setting of compensation; with appeals to CNA in Mexico and the National Water Authority in Chile; and final appeal to courts in each case.

Furthermore, in Mexico, the greater the change in the type of consumptive use of water through a proposed trade (which increases the probability of indirect impacts), the greater the scrutiny the trade receives in the approval process. All transfers of water rights must be recorded in the Public Registry of Water Rights maintained by the CNA. In general, the process can be seen as a regulatory hierarchy, with water user associations having authority over trades among individuals, the regulations of the irrigation district have primacy over the water user associations, and the CNA having authority over operations of the IDs. The Transfers among farmers in the same general locale have been commonplace for decades, with implicit or explicit CNA approval, so it is unlikely that CNA will exercise a heavy hand over these types of transfers. However, CNA intends to play a strong role in approving and brokering intersectoral trades, with particular attention to possible adverse indirect impacts.

Evidence from Chile suggests that not only are negative impacts small, but that the agricultural regions have benefited substantially from water trading. *A very important outcome of Chile's water policy is the purchase of agricultural water by urban water suppliers without having to buy land or expropriate water, as was done quite discretionaly before the new water policy was in effect.* There have rarely been negative effects in the agricultural zones surrounding water-demanding urban areas, because farmers mostly sell small portions of their rights and maintain agricultural production with highly efficient on-farm irrigation technology for the orchard or vegetable crops grown in these areas.

A study made on Santiago County *showed 587 permanent transactions inscribed in the one-year period. Thirteen percent of the trades were between farmers, representing 94% of transferred water; 85% were agriculture-urban, representing about 3% of transferred water; and 2% were agriculture-mining, representing 1% of the transferred water. (Gazmuri and Rosegrant, 1994)*

Agriculture-urban trades consist mostly of purchases of rights from farmers by the urban water and sewage companies. A typical case would be where one of the eight water companies serving Santiago buys water rights of the Mapocho river from several farmers in order to provide water to a new housing development or new industry. The farmers would usually sell a small portion of their rights, which they can dispose of because they have improved their irrigation efficiency. The farmers obtain an important amount of fresh capital in exchange for their water rights. A farmer who increases irrigation efficiency by 30 percent on a 40 ha grape farm can dispose of water rights shares equivalent to 24 l/sec, selling for $7,000-$10,000, without reducing agricultural production.

The five percent per annum growth in Chilean agriculture since reform of land and water rights also calls into question any presumption of negative area-of-origin effects on agriculture, which is the source of virtually all water sales. With the increasing value of water, the area planted to fruits and vegetables, which require more water per hectare, but far less water per value of output, than most field crops, increased during the period 1975-1982 by 206,000 hectares, replacing traditional crops and irrigated pastures that needed less water. In addition, two studies have attempted to measure the increase in aggregate water use efficiency in agriculture from 1975 to 1992. The first study found a 26 percent increase in efficiency (Munita, 1994), and the second one a 22 percent increase (Frías, 1992). Considering the lowest estimate, and taking into account that Chile's total irrigated area, with permanent rights, amounts to 1,200,000 hectares, this is equivalent to freeing-up enough water to irrigate an additional 264,000 hectares of crops of average water-use intensity. On the other hand, in a conservative estimation, an investment of about $400 million in new infrastructure would be required to generate the incremental water saved through efficiency gains generated by policy reforms.

The experiences of California and Chile thus suggests that negative indirect economic effects from water trading are small or non-existent; in Chile, tradability of water has contributed to diversification and rapid growth of the agricultural sector. Broad-based area-of-origin protection against intra-regional or intra-basin trade on vague grounds of "unreasonable impact" can suppress otherwise effective water markets, providing excessive discretionary power to regulatory agencies. Given the generally small impacts of these indirect costs of trade, it would be better to make explicit what is unreasonable, and to place the burden of proof on the area-of-origin to demonstrate negative impacts.

Protection of the environment

The evidence from the case studies shows that allocation of water by markets is perfectly compatible with environmental protection. Implementation of environmental protection in a market system is no more difficult than with administrative allocation. In fact, in California, many environmental groups have joined with urban interests in cautious support of water marketing as the way to meet growing water demands without building new infrastructure, which is seen as more damaging to the environment than water transfers. Among the three case study areas, California's water policy includes by far the most protection for the environment, followed by Mexico and Chile. In California, state law prohibits water transfers that would have an unreasonable impact on fish, wildlife, or other

instream uses. A wide range of environmental and water quality laws affect the feasibility of water transfers. Probably the most significant constraints are those imposed by the Federal and State Endangered Species Acts (ESA). Under the ESA, an endangered species is one that is in danger of extinction in all or a significant part of its range, and a threatened species is one that is likely to become endangered in the near future. The ESA prohibits the "take" of endangered species and threatened species for which protective regulations have been adopted. Take has been broadly defined to include actions (including water transfers) that could harm or harass listed species or that cause a significant loss of their habitat. This interpretation imposes severe limitations on the timing of volume possible water transfers which affect natural flow rates through the Sacramento-San Joaquin Delta. A large portion of potential future market transfers would need to be pumped through the Delta (see also below), so these limitations may seriously constrain the growth in market transfers.

In Mexico, the new water law is the first to establish strong explicit protection of the environment. The law stipulates a regulatory, rather than a market or tax/subsidy approach. The quality of discharge for non-agricultural uses must be specified in the granting of the water right, and the CNA can invoke restrictions over water use in the event of damage to ecosystems, overexploitation of aquifers, and other environmental impacts. A minimum streamflow is established for rivers, but explicit reservation of flows for environmental purposes is not made. The transfer of water rights for in-stream flow, however, is not prohibited.

Invocation of restricted or prohibited areas gives the CNA particularly strong powers to regulate water transfers which could affect the environment. The law provides that the CNA may regulate the extraction and utilization of water, and establish restricted areas or reserves by reasons of public interest: to prevent overexploitation of aquifers, to protect or restore an ecosystem, to preserve sources of potable water or protect them against pollution, to preserve and control water quality and in case of unusual water shortages or drought. Under these provisions, the CNA has full control over extraction, discharge, and transfer of water in affected areas. Some 70 percent of total irrigated area served by groundwater is currently under some form of prohibition or restriction.

In Chile, strong environmental protection is lacking in the Water Code, although several provisions allow protection of environmental interests. All major infrastructure construction (dams of more than 50,000 cubic meters or aqueducts carrying more than 2 cubic meters per second) need authorization of the DGA in order to prevent harmful third-party effects or environmental damage. The DGA is also empowered to undertake vigilance over water in natural channels for public use and will prevent the building, modification, or destruction of waterworks along natural channels unless prior authorization has been obtained. The president of the Republic, at the request or upon the report of the DGA, may declare drought zones during extraordinary dry periods for maximum and non-deferrable six-month periods. The DGA will determine, by resolution, the drought periods that are to be considered extraordinary.

Once a drought zone has been declared, if no agreement is reached between the users regarding the distribution of water, the DGA is empowered to distribute for public use water available in natural waterways and in channels that impound water from them. With the aim of minimizing the general drought-induced environmental and other damage, the DGA may suspend the authority of the users' organizations. Any holder of rights who might receive a lesser portion of water than is their due (in accordance with existing availability) will be entitled to state compensation for the lost portion. These protections will be significantly enhanced with the recent passage of the Environmental Protection Law.

The range and type of environmental protection thus vary widely across the three case studies. As with the case for protection of return flows, a balance must be struck between the benefits from environmental protection, and the costs of rejecting profitable water trades. Some analysts of the California water scene have argued that regulations and mandated water allocations for fish and wildlife have resulted in excessive protection of the environment against other uses of water, and that a market-based approach to environmental protection would be preferable (Gardner and Warner, 1994). A possible reform that would increase market flexibility and better measure preferences across all types of final demands would be to reduce mandated water allocations for environmental purposes and require that environmental interests compete for scarce water in the market. The primary economic argument in support of mandated environmental allocations is that the benefits of water allocations to fish and wildlife are dispersed across a large number of people, so it is very difficult to form coalitions to purchase water rights. However, private groups have in fact begun to purchase instream water rights in California and elsewhere. Allocation of some portion of public funds (the amount of which would be subject to public determination) for purchase of instream water would also facilitate a market allocation approach to environmental uses of water. The latter policy has already been implemented on a small scale in California. The Department of Fish and Game purchased 41,000 acre feet of water from the 1991 Drought Water and 16,000 acre feet from the 1992 bank. However, it must be noted that at least the first part of this policy would meet with strong opposition from environmentalists. Environmental groups have won substantial gains in mandating water for environmental purposes, and would likely oppose a policy that "gives back" some of these gains. In the final instance, in any society, how much environmental protection will be provided will be a matter of political choice.

The role of water user associations

It has been argued that establishment of tradable property rights in water is somehow antithetical to traditional community values, and inimical to communal management of water (Young, 1986; Mumme and Ingram, 1985). However, assignment of tradable property rights to individuals within water user associations, or even to communal groups themselves, should in fact enhance the control of these groups over water resources, better insuring access to water than is often the case with existing water user groups. In practice, turnover of irrigation systems in many countries has simply legitimized the transfer of the responsibilities for operations and management to farmers, thereby reducing the costs of financially strapped public bureaucracies. However, the turnover of costs and responsibilities has not been accompanied by change in the fundamental incentives governing water use. If well-defined transferable water rights are granted to the group, or to the individuals within the group, water user groups would have the incentive to economize on water use, and would have the legal standing to negotiate with the water delivery agency for timely and efficient service.

In both Chile and Mexico, strong water user associations play a major role in allocation of water. In Chile, user associations own and manage the physical infrastructure, monitor the allocation of water, approve water transfers subject to specific conditions, and provide the initial (and usually final) forum for conflict resolution. In Mexico, the turnover of irrigation districts to newly organized water user associations is fundamental to the establishment of water rights. Under law, water rights can be provided to individuals or groups, but there appears to be a strong preference for concessions to be made to groups,

with the groups then to grant subsidiary water rights to their members through internal processes to be authorized by the CNA.

An important question arises as to whether water rights, or full veto power over all water trades should be granted to water user groups. On the one hand, assignment of tradable property rights in water to communal groups may be more cost-effective than assigning rights to individuals in instances when internalizing bargaining within the group reduces the information, contractual, and enforcement costs relative to pair-wise bargaining by individuals. To prevent domination of groups by powerful individuals would require the establishment of transparent decision-making mechanisms within the community. It is essential in either case that the assignment of property rights is congruent with the structure of decision-making with respect to allocation of water.

On the other hand, assigning tradable water rights to a group, while preferable to most existing allocation systems, inevitably weakens the security of these rights to the individual, who is making the fundamental farming and other resource allocation decisions. The experience in California indicates that granting too much authority to water user associations can also stifle development of water markets. Recent reforms of the laws governing water transfers in the huge Central Valley Project operated by the federal Bureau of Reclamation were designed to reduce the power of irrigation districts to veto trades and to increase the flexibility of water marketing, by providing that all individuals and districts receiving CVP water may transfer it to any other entity for any project or purpose recognized as a beneficial use under State law. The affected district has approval power only over transfers involving over 20 percent of the CVP water under long-term contract with the district. This clause, allowing farmers to sell up to 20 percent of their water without approval of their local irrigation or water district or agency, has, for the first time, vested the property right to the first 20 percent of contract water directly in the individual user (Howitt, 1994).

These conditions contrast sharply with the incentives facing potential water sellers in Bureau of Reclamation districts before passage of the CVPIA. Water transfers required permission from existing irrigation and water districts in the project, and the transfer could not be detrimental to the project or to any senior appropriator. In effect, as long as any users in the district could use the water at its nominal cost, individuals could not sell water at market prices. With these legislative restrictions on gains from trade, water districts and groups of members often obstructed water trades (Howitt, 1994). Strong water user associations are a key to success of development markets in tradable water rights, but excessive power vested in the water user association is also detrimental to market development.

In Chile strong Water Users Associations have the authority to veto water transfers in artificial water courses if they cause hydraulic third party effects, or if the buyer does not finance the necessary infrastructure changes to assure no effect on water rights delivery to third parties; and also can deprive water to those who don't pay the water fees for O&M or investment repayment. Nevertheless there has been virtually no conflict between WUAs and individual water users within the WUA because the authority of the WUA is limited to specific cause, and perhaps more importantly, because the water rights are individually titled. When rights are held by the individuals there is a natural balance of power between them and the WUAs.

Infrastructure requirements for tradable water rights

Sophisticated measuring devices, division boxes, and other conveyance structures are not necessary to implement a water trading system. Effective water markets are operating in Chile (and are beginning to operate in Mexico) with conveyance infrastructure no more advanced than that in most irrigation systems in mostly developing countries. Water is usually measured only in the main channels, and thereafter, simple proportional division devices are used, which divide the water into the assigned shares in proportion to canal flow. The question of technology is more a matter of degree than an either/or situation: better technology will improve the efficiency of water markets, and increase the benefits of markets by reducing the transactions costs of trading, but significant gains from trade can be realized without highly sophisticated technology. Moreover, there is synergy between markets and technological improvement in conveyance: technological innovations in water delivery and metering will reduce transactions cost and encourage market-oriented reform in allocative mechanisms, while markets in turn can induce technological change by increasing the returns to investments (Young, 1986).

Ironically, California, with the most sophisticated technology by far in the case study areas, faces the most difficult hydrological/physical constraints to water trading, due to its unique geography. If water transfers are to be made on a large scale in California, a substantial portion of these transfers will be transported by either the California State Water Project (SWP) or the federal Central Valley Project (CVP), and will be pumped by these projects through the Sacramento-San Joaquin Delta, the 1,153 square mile region located where California's two biggest rivers converge and flow into San Francisco Bay. Forty-two percent of the state's annual runoff flows through the Delta. The SWP and CVP water facilities in the south Delta pump water to supply farms and cities in central and southern California, providing water to about two-thirds of the state's population. These projects and local facilities also provide about 60 percent of the water used in the San Francisco Bay area. The Delta is also a rich agricultural region where a combination of flat topography, mild climate and abundant water produced $375 million in farm products in 1987. Delta waters support 28 native and 28 non-native fish populations, in addition to the salmon and steelhead populations that migrate through the Delta on their journey to the ocean. Significant water trading is likely to occur in California only if a fair balance can be found among these urban, agricultural and environmental uses resolving the Delta's very complex and controversial water issues.

Strict Delta protection requirements may severely constrain the potential for an increased volume of water transfers through the Delta. In order to minimize impacts on the winter run chinook salmon, Delta smelt, and striped bass in the Delta, and to avoid disruption of service to existing contractors, pumping of water by the SWP and CVP through the Delta to meet transfer agreements has been mainly limited to the period of August through October.

In the short-term, even existing SWP and CVP contractors relying on the Delta for all or a portion of their supplies face great uncertainty in terms of water supply reliability due to the uncertain outcome of the Bay-Delta proceedings. For example, in 1993, an above normal runoff year, environmental restrictions limited CVP deliveries to Westlands Irrigation District to only 50 percent of contracted supply. Until solutions to the complex Delta problems are identified and put into place, even existing contractors relying on transport through the Delta will experience more frequent and severe water supply shortages, and the potential for more active trading of water, which would increase flows through the Delta, will be highly problematical. Relatively simple irrigation infrastructure is not an intrinsic

problem for development of water markets. Rather, it is the complex interaction of the hydrological, infrastructural, legal and political regimes that determine the feasibility of development of markets in tradable water rights. The unique geographical conditions in California, combined with the high transactions costs of verifying trades under the appropriative doctrine, and the complexity of balancing agricultural, urban, and environmental interests, are more constraining to water market development than are the relatively unsophisticated irrigation technologies in Chile and Mexico.

Privatization of water supply and management

A question that cuts across many of the issues described above is the delineation of roles between the private and public sectors in the management of a water market allocation system. While the logic of development of tradable water rights leads toward significant privatization of water supply, operations, and management, the case studies indicate that a wide variety of divisions of public and private responsibilities are consistent with establishment of tradable water rights and increase flexibility of water trading.

In California, water markets are, and likely will remain, highly regulated, and water allocation market implementation will require considerable central participation from the DWR and other state and federal agencies and projects. This is because of (1) the strong burden of proof placed on potential transferrers to verify consumptive use and lack of direct and indirect damage to third party and environmental interests under the appropriative doctrine as it has evolved under California law; (2) the necessity to balance powerful interest groups and competing final demands for agricultural, urban, and environmental purposes, a challenge which is accentuated by; (3) the unique hydrological/geographical conditions governing water transfer in California, especially the fact that a large share of future water transfers will need to be transported through the Delta; and (4) the related need for careful timing of water transfers, which will be made in most cases through storage and delivery infrastructure that is already heavily committed to existing contractors. The DWR (and the federal CVP) will therefore be expected to play a major role in facilitating transfers, including identification of transfer opportunities, determination of the amount of water available for transfer under individual transfer proposal, certification that trades do not cause third-party damages, and scheduling the actual transport of traded water in the SWP and other projects while meeting environmental requirements and contractual commitments.

The Mexican reform undertakes a significant degree of privatization of infrastructure and decision-making, while retaining public control over other important functions. As was mentioned above, in Mexico, the turnover of irrigation districts to water users was fundamental to the water law reform creating tradable water rights. Privatization of urban water and sewage companies is also proceeding quickly, with the government finalizing an international bid to operate, through a long term concession, the Mexico City water and sewage facilities, which will serve a population of 22 million people, to one or several private water companies. A key objective of district turnover is to improve the funding of and eliminate subsidies to operation and maintenance of irrigation systems. After turnover, WUAs are required to fund and implement O&M for the canals and other infrastructure under their control, with the level of fees set by the implementing regulations approved by *Comisión Nacional del Agua* (CNA). Considerable success in improving cost recovery has already been achieved, with CNA reporting that farmer payments as a proportion of total O&M have increased from 18 percent in 1988 to nearly 80 percent in 1993. These gains have been achieved both by budget restrictions on O&M outlays, and because of informal transfer of irrigation district administration to water users, as the formal turnover proceeds.

However, the CNA will retain control over dams and main (and larger secondary) channels and diversion structures both above the irrigation district level and within the district. CNA will collect a fee on WUAs to pay for conveyance of water to the district and O&M on infrastructure within the ID which is retained under CNA control. The water law also calls for approval of the construction of new water infrastructure only with the approval and participation in funding of capital costs by water users, but regulations to implement these provisions have not been activated.

Chile has undertaken the most thorough privatization of water management and infrastructure. In addition to the devolution of irrigation infrastructure to water user associations, urban water services have been privatized. The state-owned urban water and sewage city services were highly subsidized and quite inefficient, both physically and economically. Beginning in the early 1980s, the previously state-owned urban services were transformed into urban water and sewage companies. Shares are owned in different proportions by the public, municipalities, the regional governments, and the national government, and are traded in the stock markets. Since utility concessions are a natural monopoly, the maximum fees for the privatized urban water and sewage services are fixed by the Ministry of Commerce, taking into account the market price of raw water, amortization of infrastructure, preservation, maintenance, management, distribution, collection, and a certain percentage for investments in infrastructure improvement. Each utility fixes its rate, which must be below the maximum set by the government.

Privatization of urban water services has dramatic efficiency and equity impacts. Reform has contributed to the expansion of coverage of potable water in urban areas from 63 percent in 1970 to 99 percent currently, and in agricultural areas from 27 percent to 94 percent. In addition, the removal of broad based water subsidies has allowed the government to increase the level of subsidies targeted directly to the rates paid for urban water by low-income sectors of the population. This subsidy amounts to a specified monthly free quantity of water (up to 20 m3 per month) in predetermined sectors of the cities accounting for the poorest 20 percent of the population. The subsidy is paid directly to the water company.

Finally, a major innovation in Chile is creation of water rights prior to construction of an irrigation system, and requirement of consultation and approval for construction plans, together with participation in the capital cost by prospective rights holders, which establishes strong incentives for cost-effective investments in irrigation. Publicly funded irrigation construction requires active participation by potential users, commitment of at least one-third of prospective users for project development, and commitment by one-half of prospective users to acquire the infrastructure prior to the start of construction. The infrastructure constructed under this process, and those previously constructed, and state-owned, must be transferred to the users, represented by their organizations.

Private financing of water infrastructure and water management and operation in Chile has worked in favor of the poorest sectors of the population. The large reduction in subsidies generated by this policy again allows the government to target the poor, by subsidizing small farmers so that they can buy shares of water rights coming from new the new infrastructure. Private financing of infrastructure also corrected inappropriate incentives which often led to construction of unprofitable infrastructure, and continuing large capital and operating subsidies financed in large part through tax resources. This meant transferring resources from the poorest sectors of the population (who usually did not have subsidized water and spent a large percentage of their incomes in sales taxes), to the better-off who receive subsidized water. Under the new policy, these tax resources were saved through private financing of infrastructure, self-financed and regulated urban water companies, and water users associations which finance infrastructure and O & M costs.

5. Conclusions

At the beginning of this paper we noted that water policy in developing countries faces several serious challenges: to increase water efficiency in all uses; to preserve and sustain the natural resources involved in water management; to sharply reduce the enormous amounts of financial resources invested and expended in state-managed water policies; and to increase the flexibility and responsiveness of resource allocation. We then proceeded to describe the potential benefits of policy reform to establish markets in tradable water rights: empowerment of water users, provision of investment incentives, improvement in water use efficiency, reduced incentives to degrade the environment, acceptability to farmers, improved equity in the provision and financing of water services, and increased flexibility in resource allocation.

Based on the experience of the countries studied, significant efficiency gains and economic and social benefits can be expected from the establishment of markets in tradable water rights. Thus the review of experiences in Chile, México and California shows that markets in tradable water rights can be a viable alternative to cope effectively with the challenges described above. Chile's longer term experience with market allocation of water indicates important strides toward achieving the a large share of the potential benefits from markets in tradable water rights. México, after a broad internal debate, passed a new water law in 1992 that shifted from state-managed water policy to a regulated market- oriented policy with tradable water rights. Water trading will initially be closely supervised, but the law includes a number of provisions that will liberalization of water trade as the water users become more involved in operation and management of water and gain experience in water trading. California, with a highly regulated institutional framework and a legal tradition of appropriative water rights that are far from the ideal tradable rights, has nevertheless evolved innovative policies which have expanded the use of market transfers to meet growing demand in urban, environmental, and high-valued agricultural uses. Market transfers have become an important element in drought management policies.

Chile adopted a comprehensive, market-oriented water policy nearly twenty years ago, and with the longer experience with a market system, has shown important achievements in solving the above-mentioned policy challenges. Tradable water rights in Chile have fostered efficient agricultural use of water, which has in turn increased agricultural productivity, generating more production per unit of water. The market valuation of water at its scarcity value has induced farmer investment in on-farm irrigation technology which has saved water to irrigate more area or to sell to other uses; has induced a shift to high-valued crops which use less water per unit value of output; and has given farmers greater flexibility to shift cropping patterns according to market demand through the purchase, rent and lease of water.

Market allocation of water has also induced improved efficiency in urban water and sewage services because the water and sewage companies can no longer get free water from the state, through expropriation from farmers. When incremental water could be obtained for free, there was no need to improve either physical efficiency (pipes, metering, etc.), or economic efficiency. Secure water rights held by the urban companies and an active market have encouraged the construction and operation of improved treatment plants that sell water for agricultural or urban use. In addition, the Chilean water policy, by reducing huge construction and O&M subsidies to better-off farmers and urban water consumers, has freed-up public resources that have been utilized to provide direct, transparent, and efficient targeted subsidies for poor urban water users and small farmers.

Given the precarious and poorly-defined water rights in most developing countries, comprehensive reform of water law is the most effective means of moving toward markets in tradable water rights. To form the basis for allocation of water through tradable rights, the law should be simple and comprehensive, should clearly define the characteristics of water rights and the conditions and regulations governing the trade of water rights; establish and implement water rights registers; delineate the roles of the government, institutions, and individuals involved in water allocation and the ways of solving conflicts between them; and provide cost-effective protection against negative third party and environmental effects which can arise from water trades.

The experiences in Chile, Mexico, and California also provide guidance in resolving the complex issues that arise in the process of implementation of a system of markets in tradable water rights. Issues that must be dealt with include the initial allocation of water rights, definition of rights as prior or proportional, the treatment of return flows, negative indirect economic effects, protection of the environment, the role of water user associations, infrastructural requirements, and the role of public and private institutions. Some of the these questions appear to have relatively simple solutions. Basing the initial allocation of water rights largely on historical water use, combined (in Chile) with redistribution of concentrated water rights holdings, offers substantial gains in security to farmers and other water users. Given the precarious nature of existing water rights in most developing countries, the establishment of secure and well-defined tradable rights will in most cases be perceived as an increase in wealth and equity. Highly sophisticated infrastructure is not required to implement water markets; effective water markets are operating in Chile with conveyance and distribution infrastructure no more sophisticated than that found in most developing countries.

Other implementation questions are more complex, and the approach chosen often rests upon the balance that is desired between the degree of regulation to protect various interest that are affected by water trades and the level of transactions costs in water trading. However, the case studies show that a variety of legal, institutional, regulatory solutions to these issues are compatible with functioning markets in tradable water rights.

California, with a legal tradition in many ways inappropriate for water marketing, strongly entrenched interest groups with high stakes in water, and difficult hydrological and physical constraints to water transfers, has adopted a highly regulated approach to water markets with relatively high transaction costs. Chile's water law, while providing significant protection from direct adverse impacts from trade, places the emphasis on water market liberalization with low transactions costs. Mexico has taken the middle ground, with a law that maintains strong government control of water trading, but that also allows for rapid relaxation in controls as experience is acquired in the market allocation of water.

Even comprehensive water law reform allows a phased approach to implementation, which can begin with carefully regulated markets that are progressively opened up as market experience is gained. Greater regulations at the outset will limit the size and scope of the market, and will likely reduce the efficiency gains (and equity gains, to the extent that they perpetuate large general subsidies which favor relatively well-off irrigators and urban water users). The benefits produced by the Chilean reform show that the losses incurred from excess regulation of the market could be very large, but this may be an appropriate trade-off for risk-averse governments in the early stages of undertaking fundamental reform. *An example of these losses are the huge O&M costs on Mexico's Water Districts operated by the CNA, during the process of shifting them to the users. This last ones have urged, very strongly, to speed the turnover and, in the cases they succeeded, have demonstrated they can save large amounts of money.*

Broad-based trends in the developing world are creating strong incentives for comprehensive water reform incorporating establishment of tradable water rights and the development of markets in these rights. Existing inefficient water systems are under heavy pressure due to the increasing economic value of increasingly scarce water; the rising budgetary costs from highly subsidized capital development and operations and maintenance; and general economic liberalization, which boosts the cost of maintaining inflexible water allocation systems that cannot respond to changing incentives. Development of water allocation through markets in tradable water rights offers a viable approach to meeting these challenges, and should receive serious consideration from developing country policy makers.

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