ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN

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PRICES, PROPERTY AND MARKETS IN WATER ALLOCATION

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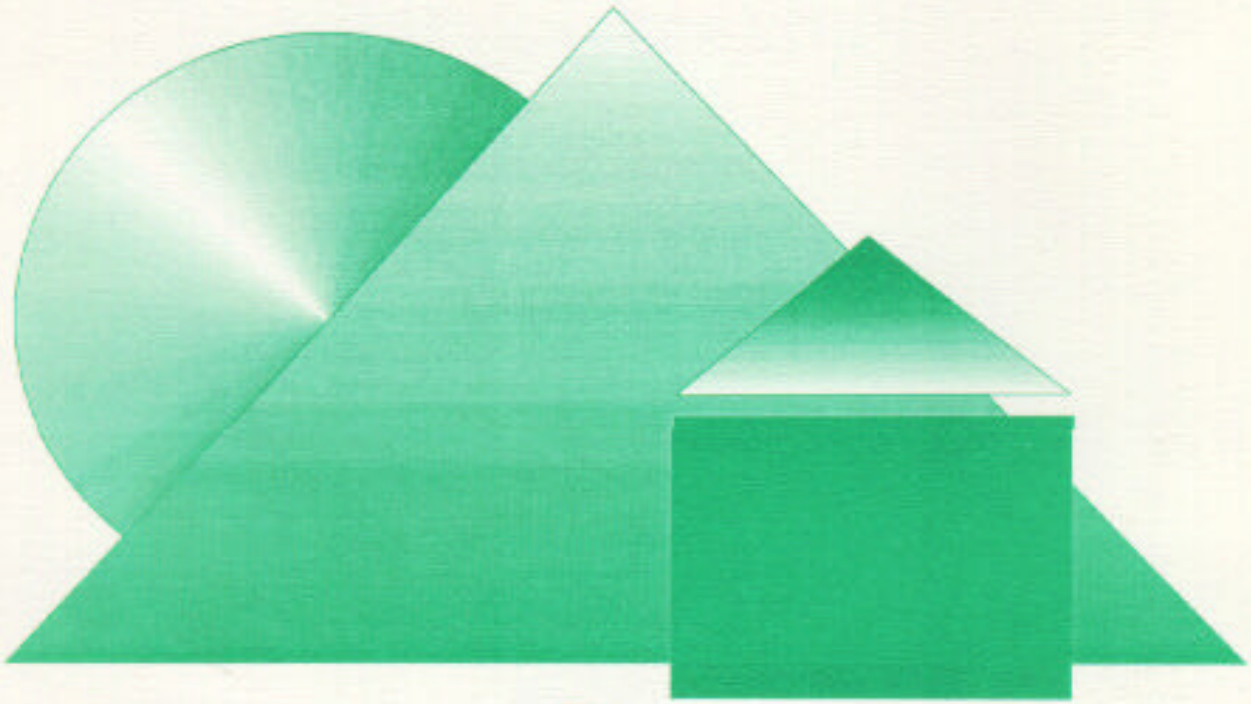

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Contents

Abstract

This paper examines the means to incorporate the use of market signals through prices into water resources management with the objective of improving efficiency in the allocation of water. It reviews a vast body of recent literature on tradable resource use rights as well as actual experiences with implementing tradable water rights programmes both in Latin America and in the rest of the world. The issues discussed include the conditions required for a well-functioning water market; the potential strengths and weaknesses claimed for markets as a means of water allocation; the characteristics of the operation of a water market; types of transactions; the initial allocation of water rights; design issues, including permanent and time-limited water rights, and hydrological security and allocation rules; the limitations of markets and the factors that can adversely affect their performance, including externalities (return flow, instream and area-of-origin effects), market power, transaction and transportation costs, and steps to mitigate them; and opportunities for expanding the role and scope of water markets.

Introduction

After many years of discussions at international forums and among international agencies active in water management, finally in the Dublin Statement, adopted at the International Conference on Water and the Environment in January 1992, the rhetoric of international meetings on water resources management recognized that water is essentially an economic good. The fourth Principle of the Dublin Statement asserts that: "Water has an economic value in all its competing uses and should be recognized as an economic good". This is not a very new proposal. Economists interested in water resources management have long argued the necessity to recognize that water is an economic good and not to treat water as having "unique importance" but as one good among all others.

> "This is not to deny that, as a commodity, water has its special features; for example, its supply is provided by nature partly as a store and partly as a flow, and it is available without cost in some locations but rather expensive to transport to others. Whatever reason we cite, however, the alleged unique *importance* of water disappears upon analysis" (Hirshleifer, De Haven and Milliman, 1960).

If water is an economic good then it should be possible to govern its allocation through the market. For many years, it has been widely recognized in the literature that in the absence of markets it is difficult, if not impossible, to evaluate the real demand for water-related services because demand-functions cannot be estimated in such a situation (Fox and Herfindahl, 1964). In the place of markets and the signals for efficiency in investment decision-making which they provide numerous, elaborate and unsatisfactory substitutes have been suggested. All these substitutes have in common that they provide only poor, if not incorrect signals, that they are essentially arbitrary and that they provide no real solution to the problem of achieving an efficient allocation of water. The only solution is to place as great a reliance as possible on prices and, therefore, on markets in the process of allocation of water and the related investments in productive services. If efficiency is the goal then the role of administrative allocation must be restricted to those few areas where markets cannot be developed and to the regulation of natural monopolies.

> "In light of the information problem, there seems to be little hope that administrative approaches can allocate water even with only minimal efficiency among the processes that result in marketable goods. It is not reasonable to expect a staff and a ... board to know what water is worth in every water use, which is necessary in order to know the economic efficiency of each board decision. The solution to the information problem will likely necessitate applying a market-like process for allocating water to produce market goods. The regulatory approach and the limited funds ... can then be focused on the areas where they are needed, which is in deciding water needs for the nonmarket goods" (Lynne, 1988).

It must be carefully considered, however, when advocating the introduction, extension or maintenance of public intervention in water allocation how effective it can be. Administrative approaches to water allocation are often criticized for their implicit reliance on "the ability of the few decision makers within a centralized structure to act objectively, omnisciently, and

responsibly in pursuit of the public interest" (Anderson and Leal, 1988). As was commented in the debates more than 30 years ago on this issue in the United States of America,

> "... that while public intervention was *necessary*, it need not be *sufficient* for improvement in efficiency. For intervention to be also a sufficient condition for improvement in efficiency, appropriate criteria must be developed and, assuming in the final analysis that there is a feasible way to do so, applied with sufficient fidelity to ensure that the objectives of public intervention in the interests of efficiency are reasonably approximated" (Krutilla, 1966).

In discussing public policy towards water management and the issue of using prices and introducing markets as a major tool for water allocation and, therefore, for water management, it has to be understood that "controlling the use of water courses is a basic economic problem of resource allocation" (Freeman and Haveman, 1971). A fact equally true for the quality and quantity aspects of allocation.

> "It is interesting to reflect that the large and lengthy debate on public policy for water management in the 1960s in the United States led to little innovation in water management practice. Water management and water allocation decisions remained largely in the hands of national or state bureaucratic agencies. The use of both prices and markets and river basin institutions has been of only marginal significance until comparatively recently with the increasing use of markets in water allocation in the western states of the Union" (Freeman and Haveman, 1971).

To come closer to the present and to the water management issues current in Latin America and the Caribbean, the increasing private participation in water management has brought with it as a corollary the wider opening of water management to market forces and increased the application of economic principles to water allocation decisions, at least in some areas. It has also increased the interest in directly employing prices and markets as the main tools for water allocation. One sign of this interest is the amount of literature discussing the experience of the few places where water markets exist, particularly the amount of interest shown in the Chilean experience.

The adoption of a market approach to water allocation in Chile has attracted much interest from all over the world, although serious economic analysis remains largely absent from the discussion of the Chilean experience. The findings of the one economic analysis that has been made suggests the importance of remedying this lack of serious economic evaluation (Hearne and Easter, 1995), but there is certainly much more literature on the current Chilean system than on any previous water allocation system adopted in any other Latin American country.

There are several reasons why the interest in water markets, as a means of water allocation, is increasing in many Latin American and Caribbean countries, as well as in the world as a whole. The water economy of many countries is entering a mature phase characterized by inelastic supply of new water and increased interdependencies among water uses and users (see Table 1). As the water economy matures, the attention of participants in the policy process is gradually shifting from concern with the expansion and subsidy of the development of the water sector to revenue generation, demand management, and reallocation. The driving force behind the interest in the use of prices and markets is the

perception that there are substantial gains from trade to be realized from the introduction of water marketing, gains which represent the opportunity cost of failing to modify existing water institutions in ways which will promote more economically efficient use of available water supplies. Moreover, there is an additional perception that other allocative mechanisms will not achieve the desired increases in efficiency in water use.

Table 1

Characteristics of mature water resource systems

Item	Mature phase	Item	Mature phase
Long-run water supply	Inelastic	Competition for water among uses	Increasing
Demand for delivered water	High and growing; elastic at low prices, inelastic at high prices	Conflicts and externalities	Rising water tables, land salinization, saline return flows, groundwater salinization, water pollution, etc. are typical
Physical condition of impoundment and delivery systems	A substantial proportion is ageing and in need of repair and renovation	Social cost of subsidizing increased water use	High, and rising

Source: adapted from Randall (1981).

Historically, new users could obtain water through appropriating water rights to which no previous claims had been established. At present, in the countries of Latin America and the Caribbean, although overall supply is plentiful, in many areas with concentrated economic development, all surface water and much of groundwater is appropriated. Alternatively, historically, new water supplies have been obtained through the construction of storage and conveyance facilities, projects usually undertaken with the help of substantial public subsidies. It is now widely recognized that this policy has led to investments in projects, whose real economic viability is in doubt, to the wasteful use of water and to negative effects on the environment.

Moreover, in many areas, as the best and the least expensive water sources have been developed and attention increasingly turns to the more expensive and locationally disadvantageous sources, the costs of new project has begun to escalate. Successive increases in reservoir storage capacity produce diminishing returns in the safe yield. Consequently, as the options for increasing water supplies through the manipulation of surface flows diminish and the subsequent increases in storage require larger and larger investments, the costs of new projects begin to rise dramatically (Frederick, 1993). This is occurring as public subsidies have been significantly curtailed and even disappeared in many countries as a result of limited public budgets, changing social priorities, lack of political support for traditional methods of financing water development, and growing concerns about the environmental costs of new projects.

On the other hand, due to population growth, urbanization and economic development, per capita water availability is decreasing. Concurrent with growing demand from agricultural, drinking water supply and sanitation, industrial, and environmental uses, there have been significant structural changes in national economies. At the same time that demands for both instream and withdrawal uses of water expand with economic and population levels, water pollution diminishes the available quantities of good quality water and increases the costs of treatment. It can be expected that there will be increasing demands to reallocate supplies among uses.

Once markets are introduced and property rights established in water, it can be expected that transfers of water rights will occur whenever the net benefits from a reallocation are positive, until marginal values, net of transaction and conveyance costs, are equalized among water users, uses and locations. Trade will continue until all water users are indifferent between buying and selling water rights. Since market transactions are precipitated by the difference in the value of water in alternative uses and locations which must be large enough to outweigh the transaction and transportation costs of obtaining water through the market, water markets are unlikely to emerge, be active or operate effectively where water is in surplus and or where there are alternative sources of low-cost water. It is for this reason that market activity often intensifies in periods of insufficient water supplies remaining less active or latent in periods of normal supply conditions. In Chile, for example, water markets are more active in those basins in the north of the country where water is more scarce (Donoso, 1994). Also in Texas, although transfers of surface water rights have been theoretically possible for several decades, they did not begin until the first river basin was fully adjudicated over 20 years ago with the major activity concentrated in the Lower Rio Grande Valley where there is virtually no groundwater (Chang and Griffin, 1992).

The evidence suggests, as the discussion in this paper amply demonstrates, that water markets work, but that to make them work well requires a clear understanding of the institutional and legal framework, the establishment of clear rules and regulations governing exclusive property rights, the necessity for simple transfer mechanisms and, the corollary, of a minimum of bureaucratic interference in the market. It is these necessary components of a water market which are discussed in this paper. In addition abundant examples are provided of the working of water markets in practice and of innovations that have been made in their working as experience has been gained.

At the same time, it is recognized that the introduction of water markets is by no means a universal solution to the problems facing water resources management. A water market is a management tool. It is a tool, however, which spreads the burden and difficulties of management among a larger population, permits greater participation in management decisions and can introduce greater flexibility into management systems. At the same time, however, the establishment of a water market demands new skills and new attitudes from the public administration, judicial systems and water users, as well as, investment in registration of rights, monitoring and measurement systems, and possibly in improving water distribution and transportation systems. On the whole, "... the prerequisites needed for a viable water market are the same as those needed for good water management" (Simpson, 1994b).

I. Water markets and water allocation

In a water market, water is allocated at a price set by the free exchange of some type of property right to the use of water either for a limited period of time (a lease) or in perpetuity (a sale). It is the interactions between the buyers and sellers of rights which comprise a water market. The water market is the institution, formal or informal, which facilitates the exchange of water rights among buyers and sellers (Cummings and Nercissiantz, 1992). Water markets are distinguished from other allocation processes by the following characteristics (Colby, 1988):

- The transfer of water is the real purpose of the transaction and the value of water is distinct from the value of other goods and services involved in the transaction. A water market exists where water rights are commodities with an identity distinct from other real property. There are many examples of what have been called "implicit" water markets, where water is sold as a part of a land transfer, although the purpose of the transaction is to obtain water (Colby, Crandall and Bush, 1993). Such transactions cannot be considered as "water markets", but more as examples of a means of evading inefficient bureaucratic or legislative restrictions.
- The motivating force is the mutual perception by potential buyers and sellers that the transaction is in their own best interest given the alternative opportunities available to them; consequently, reallocation is wholly voluntary.
- No central authority determines, although it may condition or regulate, price and other terms of transfer; they are generated in voluntary transactions negotiated between willing buyers and sellers.

For a market to ensure flexibility in the allocation of existing water supplies, it is necessary only that within any individual market there is a tradeable margin subject to low-cost reallocation, if only a small part of total supply (Howe, Schurmeier and Shaw, 1986b). Since the volumes of water that can be expected to be reallocated are generally not large, water markets can be expected to normally be relatively small or "thin". The number of transactions does not say much about the ability of a market to efficiently reallocate water resources in response to changes in the value of marginal productivity of water. The number of transactions is a function of many factors, including the initial allocation of property rights.

A. Required conditions for trade

Efficient construction of any market requires the existence of the necessary conditions for trading to occur: (i) well-defined property rights; (ii) public information on the supply of and the demand for water rights; and, (iii) the physical and legal possibility for trading to take place (Curie, 1985). Of these three necessary conditions by far the most important is the existence of well-defined property rights. In the case of water, property rights define and limit the rights and duties of their holders relative to one another and to the rest of society to the use of a certain amount of water, which may be defined either volumetrically or in terms of shares of a stream or canal flow. If rights are poorly defined, market processes cannot be relied upon to allocate water resources efficiently. It is a basic responsibility of governments, as far as markets are concerned, to define, allocate and enforce property rights in water. Government policies play a critical role in defining the institutional setting for market operation and provide the basis for market activity by defining, allocating and enforcing water rights.

The fugitive and elusive nature of water can present problems in the establishment, definition and enforcement of property rights, which are the essential foundation of any market allocation mechanism, but they are not such as to "rule out either the possibility or the desirability of using prices and regulated markets to introduce economic incentives to restrain use, encourage conservation, and facilitate reallocation of supplies" (Frederick and Kneese, 1988). In fact, it seems to be possible that "through careful design of both property rights and market limitations, much can be achieved by relying upon market incentives" (Griffin and Boadu, 1992).

1. Property rights

The way property rights are defined will structure the incentives and disincentives which members of society face in their decisions regarding water ownership, use and transfer. In order for market participants to estimate the value of a water right, they must be able to form secure expectations about the benefits and costs associated with owning and transferring it and the degree to which it is protected from impairment by others (Colby, 1988). Only on that basis can they make economically rational decisions about water use and transfer. If property rights are not well-defined, the consequent uncertainty will reduce the expected value of the rights and the incentive to engage in trading (Shabman and Cox, 1986). To produce efficient resource allocation through the market the definition of property rights should satisfy the conditions of specificity, exclusivity, transferability, comprehensiveness, and enforceability (Tietenberg, 1988; Saliba and Bush, 1987):

- The rights and duties of water rights holders relative to one another and to the rest of society should be specified and enforced so that they can form secure expectations regarding the benefits stemming from their rights. Conditions that affect the water rights, their transfers, and the duties of their owners should be clearly defined, preferably as a part of the right or in the body of law which specifies the rights of the owners. The right must be defined in readily understood terms and be easily measured in the field using practical methods (Simpson, 1994b).
- If water markets are to result in efficient water allocation and to produce appropriate price signals, the buyers and sellers, and not third parties, must enjoy all the benefits and bear all the costs associated with owning, using and transferring the water rights.
- Water rights must be easily transferable at low cost through either sale or lease and not be tied to particular sectors, uses, priorities or to other property.
- Water rights must be described in all their necessary attributes (e.g., the quantity diverted, the timing, and places of diversion, use and return) that generate value and can affect other water users. Evidence from water markets in the western United States suggests that market prices are strongly influenced by specific water right and transaction characteristics (Colby, Crandall and Bush, 1993). On the other hand, since markets operate more efficiently when the commodity being traded is homogeneous, the definition of the right should not be excessively detailed. The more detailed the definition of the property right in water, the greater will be the heterogeneity among them and the transaction costs for potential buyers and sellers, and hence the more difficult it will be to organize a market (Howe, Schurmeier and Shaw, 1986b).
- Water rights holders must be able to capture the benefits associated with water use and transfer decisions. "Since rights cannot be perfectly enforced, ownership will always be probabilistic; but when the probability of capturing benefits from a use is

low, it is less likely that the owner will devote the resource to that use" (Anderson, Terry, 1982). Water rights must be secure from involuntary seizure or encroachment by others, including the State. Enforcement, via a court system or by mutual control, is needed to ensure the validity of water rights. The water right must be registered and recorded to minimize the possibility of dispute over ownership. In order to enforce user rights it must be possible to monitor water use by individual users, detect violations and the legal ability and authority must exist to deal with the violations. Sanctions should represent a credible threat and induce compliance.

2. Information

The publically available information on the supply of and the demand for water rights must include the means to identify willing buyers, sellers and intermediaries or brokers, and the means for entering into enforceable contracts. Hydrological information is also required to permit the right to be defined. Various types of information are essential for rational decision making by water rights holders, e.g., on legal and hydrologic characteristics of water rights, the cost of alternative means of obtaining water. This implies the existence of a good data and monitoring systems.

3. The possibility of trade

A clearly defined set of transfer rules are necessary to permit market transactions to take place when buyers and sellers determine. Transactions should be contingent only upon compliance with a known set of trading rules or transfer criteria. This is a prerequisite for a continuous water market. When the transfer rules are not known with certainty before a transaction is contemplated by the economic agents and potential market participants cannot predict during their negotiations whether or not the proposed transaction will be approved, there is no incentive for continuous market-like decision making (Curie, 1985). There must, also, be the physical possibilities for the transfers produced through trade to actually happen, conveyance systems, monitoring systems, etc. The seller must be able to physically move the water to a suitable point or the buyer must be able to take delivery and convey it to the point of intended use (Price, 1994). This may require easements or the purchase of rights of way across the property of others.

4. Market activity

Market transactions occur when both potential buyers and sellers perceive that there are economic gains to be captured by transferring water to a purpose, place or time of use in which it generates higher net returns than under existing use patterns. Transfers occur automatically whenever the net benefits from a reallocation are positive until marginal values are equalized among water users, uses and locations. Trade will continue until all water users are indifferent between buying and selling water rights. Three conditions must be satisfied if a market transaction is to take place: (i) the seller must receive a price offer that at least equals both the returns foregone as a result of the water rights given up and the transaction and transportation costs born by him or her; (ii) the buyer must expect the returns from the purchase to exceed both the price paid to the seller and the transaction and transportation costs born by him or her; and (iii) for the buyer, the total costs associated with the market acquisition of water rights must be less than the costs of the least expensive alternative water supply source (Colby, 1988).

Since market transactions are precipitated by the difference in the value of water in alternative uses and locations which must be large enough to outweigh the costs of obtaining water through the market process, water markets will become active only where and when water is sufficiently scare, and hence valuable. Conversely, water markets are unlikely to become active where many water rights remain unappropriated, where water supply investments continue to be favoured over reallocation, where transportation and transaction costs are very high, or where there are other sources of low-cost water.

B. Types of transactions

One of the principal benefits of water markets are the almost unlimited possibilities for water reallocation with the only real restraint the ingenuity of the trading parties (Driver, 1986). Water rights transfers can take a variety of forms, each serving a different operational purpose in a water resource system (Israel and Lund, 1995). The choice of the form of water transfer depends on the structure of the market, the legal and third party considerations that the transaction must accommodate, the definition and characteristics of the water right, the transaction costs, the characteristics of supply and demand, other local conditions, and, above all, the needs of the parties to the transaction.

1. Sales

The permanent transfer of title, including all benefits, costs, risks, and obligations associated with the right is usually a response to long-term changes in demand and supply conditions which increase the marginal value of water in some uses and decrease it in others. Sales are "the preferred market structure when the goal is to satisfy permanent demand shifts" (Howitt, 1997). The permanent transfer of water rights through sales can be expected to be less frequent than lease contracts.

Sales are common in intersectoral transfers, with irrigated agriculture being the dominant water seller and urban users the principal buyers. In the western United States, for example, while intra-agricultural transfers occur in many areas, water transfers out of agriculture to municipal and industrial uses is the predominant form of market transactions (Saliba and Bush, 1987). In Chile, intra-agricultural water sales, as well as intersectoral sales, are common in many areas (Hearne and Easter, 1995; Gazmuri and Rosegrant, 1994).

2. Lease contracts

The leasing of water rights involves the sale of water, but not of the water right. Under a lease, the title to the water right remains with the lessor and at the end of the contract, the right must be returned. Leases are a preferred market response to short-term changes in demand and supply conditions. These operations are commonly referred to as constituting a spot market for water.

Water users may find it advantageous to engage in lease contracts for a variety of reasons. The lessor has an opportunity to earn revenue in the temporary trade of surplus water rights while not giving up water rights. Leases are particularly useful when users need to accommodate: a short-term demand for additional water; a long-term but variable demand; any use that has a predictable and fixed life span; a

use of uncertain duration, e.g., a farmer facing variable commodity prices; highly variable supplies, e.g., where it is not economical to transport water in periods of sufficient water supply; water users' unwillingness or inability to commit the resources necessary to buy the water right or the desire to limit their ownership of water rights; and unexpected events (Shupe, Weatherford and Checchio, 1989; Saliba and Bush, 1987).

Under a typical lease contract, the lessee pays the owner of the water right (the lessor), generally in periodic instalments, but there can also be an up-front payment to initiate the lease. Lease contracts are often renewable. The length of a lease, in irrigation districts, is typically a single season, but it can be longer, even several decades. Leases can be, on the other hand, very short, sometimes for only a few hours. In the short-run, leases are usually a cheaper source of water than permanent transfers, but water can and will fluctuate in price, water supplies are only secure until the contract expires, there is also an expense in the constant renewal costs for those who depend on short-term leases, and there is a risk of default, for the lessee has only a contract as protection, not a property right (Scott and Coustalin, 1995).

Leasing arrangements can accommodate the most varying needs. The flexibility of leases makes them an attractive option for many users, and rental or lease markets are often very active, particularly among neighbouring water rights holders in irrigation districts. Leases, often of informal nature, are usually the predominant form of market transactions. In informal markets, most transactions are in the form of short-term leases, because difficulties with contract enforcement impede the permanent transfers of water rights.

In Chile, for example, leasing has been a much more active form of water reallocation than water rights sales (Trabajo de Asesoría Económica al Congreso Nacional, 1996). Perhaps the most common transaction is rental or leasing between neighbouring farmers whose water requirements differ through the cropping cycle (Gazmuri, 1994; Gazmuri and Rosegrant, 1994). In California, as well, water marketing is characterized by an emphasis on seasonal spot markets (Howitt, 1997).

A particular form of lease is the leasing-back of purchased rights, usually to the original owners and often for a nominal payment, when rights are bought in anticipation of future needs. A lease-back permits the new owner to receive benefits from the water during the holding period. Moreover, in those jurisdictions where a water right can be lost after a period of non-use, it ensures the continued beneficial use of water rights and acts as a protection from forfeiture. Under a conditional lease-back, water rights are generally leased back to the original owner, except in dry years.

3. Option contracts

Option contracts, also known as contingent or interruptible water markets, are a long-term agreement to lease, less commonly to sell, a water right when a given contingency occurs, typically a drought (dry year option contracts). Many of the benefits of option contracts might be secured from short-term leases without long-term commitment, but leasing could increase participants' income risk and result in higher transaction costs, including investment in delivery systems and measurement costs of assuring compliance (Hamilton, Whittlesey and Halverson, 1989). There are examples of their use in both the United States and in Chile. A typical arrangement, in Chile, is the payment by a fruit farmer of a pre-negotiated fee to a farmer growing annual crops for an option on water supply in the case of drought (Thobani, 1997).

Option contracts are commonly used to transfer water from irrigated agriculture to non-agricultural users during periods of low stream flow. Dry year option contracts are an attractive alternative when water users have adequate water supplies in normal years. Such contracts can provide supplies during droughts at a lower cost than purchases or leases. A study of the use of option contracts for temporary use of irrigation water for providing drought insurance for urban water agencies for a case study area in northeast Colorado found that this approach is economically viable under a wide range of conditions (Michelsen and Young, 1993).

Option contracts are particularly attractive because the lessor maintains secure long-term water supplies, receives compensation for the option, including that for the income lost when the option is exercised and for the additional complexity introduced in planning business activities, and retains access to water during normal supply conditions when the option is not exercised. For the lessee, the contract provides a means of obtaining additional water supply, under predetermined conditions, whenever a given contingency occurs and at a specified price.

Option contracts are complex. In part, this is due to the need to address the risk to the lessee that the water right will not be available when the time comes to exercise the option. In part, this is due to the concern of the lessor that the contract limits his or her property rights and may limit the ability to benefit from future transactions, e.g., an opportunity to sell, although this issue can be addressed by including in the contract the "right of first refusal" which allows the seller to retain the option of selling the water rights before contract termination, but gives the option holder the right to match the offered price (Michelsen and Young, 1993). In addition, to produce the greatest benefits, option contracts require long-term contractual commitments, often up to twenty or more years, a contract length which can present many uncertainties.

Compensation is often adjustable over time to allow for changes in water use, production costs, technology and other market conditions. Various methods of payments can be used, a lump sum, annual payments, or a combination of annual payments with lump sum when the option is exercised. The latter is a particularly attractive alternative, because neither party needs to fully anticipate the number and severity of interruptions over the entire contract period (Hamilton, Whittlesey and Halverson, 1989). Sellers might be compensated in kind, for example by lower rates for the buyer's production, as in the case of irrigation to hydroelectricity generation transfers, farmers can be compensated by lowing rates for irrigation pumping power.

C. The market as a system for water allocation

The desirable characteristics for an ideal water allocation system include flexibility in the allocation of water supplies, security of tenure for established water users, the capacity to confront the water users with the full opportunity cost of water, predictability of the outcome of the reallocation process, equatability and fairness, and the capacity to reflect collective, public and social values (Howe, Schurmeier and Shaw, 1986b). Economic growth and efficiency require a balance between flexibility and security. Although security of tenure can cause a reduction of flexibility, and vice versa, both can be achieved simultaneously as long as users can voluntarily respond to incentives for reallocating water supplies.

Water markets are ***flexible*** because they are by their very nature a decentralized and incentive-oriented institution, rather than centralized and regulatory. Transferability of water rights in the market provides the freedom to reallocate water as economic, social and environmental demands and conditions change. "In a dynamic society with continually changing values, it is this transferability which insures flexibility. Entrepreneurs continually have new and better ideas of how to utilize resources. It is their offers to buy and sell these resources that generate progress. If transferability is not allowed, there is no effective way for the system to respond to changes in demand and supply" (Anderson, 1985).

With transferable water rights, marginal values for water, net of transaction and conveyance costs, are equated across water users, uses, and locations. The equalization occurs because the market provides both an incentive and a means for water users to reallocate water rights to higher-value uses whenever reallocation would generate positive net benefits. The transferability of water rights in the market enables new uses and users to emerge and obtain water supplies, and prevents waste and encourages water conservation. It also provides a continuous incentive for adoption, research and development of superior water utilization, conservation and production technologies. A market based system of water allocation will be, therefore, both resilient to shocks and open to take advantage of opportunities.

Markets require ***security*** of tenure, which in turn helps encourage efficient use, resource conservation, and capital investment. Security of tenure of water can also help strengthen and consolidate the autonomy of water users organizations. Security of tenure and the possibility to acquire water rights in the market encourage investment and growth in activities that require secure water supplies. The fact that in a market water rights are reallocated by voluntary exchanges allows market systems to defuse potential political conflicts over water allocation (see Box 1).

Box 1

Water markets and conflict resolution

Many studies consider only the economic benefits of water marketing. There is, however, a political dimension to the implementation of a system of secure and transferable water rights. The definition and clarification of property rights "offers significant potential for minimising the costs of conflict of use in multiple use resources" (Pearce, 1989). On the other hand, markets can help defuse some of the intense conflicts over water allocation.

"Market systems have a tendency to defuse political conflict, largely because anyone who obtains a resource must pay the prior owner a price that satisfies that owner" (Williams, 1983). Market transfers are always voluntary transactions in which traders will only participate if they believe that it is in their best interest given the alternative opportunities available to them. Administrative allocation, in contrast, often generates intense conflicts because granting a water right to one user necessarily precludes another and there is no automatic pecuniary compensation for the basin of origin. Water markets change the nature of bargaining over water transfers: "instead of political wrestling, with the losing region defeated by the winning region, the bargaining can become a process of mutually advantageous exchange" (Williams, 1983)

Markets, by providing incentives for water conservation and wastewater treatment, can help reduce conflicts between environmental interests and water users. Ecological economists often prefer property-right systems to pricing systems because "property-right systems define the ecological limits and then leave the market to work out what prices and charges are necessary to keep use within those limits across space and through time. On this view, property-right systems tend to be ecologically more dependable than pricing systems ... governments routinely fail to vary prices in response to changing economic conditions and opportunities ... When a property-right is used to define the limit, however, market processes take over. Value is determined by market opportunity within ecological limits" (Young, 1997).

While market transactions guarantee security of tenure to buyers and sellers, the rights of third parties are vulnerable to externalities from water transfers. If water users do not face all the costs and benefits associated with their decisions, then their decisions may be beneficial to them even though they are actually inefficient from an overall social perspective. Thus, to ensure that market transfers do indeed produce net social benefits, water marketing must be conducted in an institutional framework which causes the buyers and the sellers to take account of third party impacts without unduly restricting water transferability.

A market directly confronts - by setting a market-clearing price and making current and potential market participants aware of the ability to sell and buy at that price if desired - water users with the real ***opportunity cost*** of their use and transfer decisions and forces them to take this opportunity cost into account. "If the owner is to be fully aware of the opportunity costs of his actions, property rights must be transferable. When the owner is not allowed to transfer his resource to another use, he will not consider the full opportunity costs of the other use" (Anderson, Terry, 1982). Water markets would correct deficiencies, therefore, in water allocation irrespective of the water pricing policy followed by the authorities. "Since water would be priced (in the rights market) at its opportunity cost to the user, it would tend to be efficiently used even if the charges collected by the water authorities failed to cover resource cost in total or at the margin" (Randall, 1981).

The principal advantage of a market is the ability to gather, process, and use information effectively, an ability which is irreplaceable. Demand and supply conditions continuously change, and this information is fragmented and dispersed among all actual and potential water users and both time and place specific with a high variance across localized ecosystems. If public authorities had the information necessary to make trade-offs between

users, including information about the value of water in all alternative uses, and demand and supply conditions for every user, regulatory policies could be determined to ensure efficient resource allocation. Given that public authorities cannot acquire such information at a reasonable cost, non-tradable water rights systems cannot achieve economic efficiency and equity, and are likely to result in the allocation which is rigid over time and unresponsive to changing social values (Howe, 1996 and 1997b). "There is no way that a well-intentioned bureaucrat can know what constitutes a beneficial use without market transactions. It is the trading of well-defined and enforced property rights which will enable individuals with 'the knowledge of the particular circumstances of time and place' ... to coordinate their knowledge" (Anderson, 1985).

A continuous trade in water rights generates prices that by coordinating dispersed information and preferences indicate the opportunity cost of water or its relative scarcity. Price is an information-rich signal which summarizes all information available to market participants and motivates appropriate levels of individual action in response to changing demand and supply conditions, thus performing the crucial rationing function in allocating resources to different uses and users. Thus, transferable water rights create a system of economic incentives in which those who have the best knowledge about returns to water in their intended use - water users themselves - are encouraged to use that knowledge to allocate water to higher-value uses and hence maximize the economic value obtained from the scarce resource with a minimum of bureaucratic apparatus. Obviously, the extent to which observed market prices accurately measure the scarcity value of water and encourage its efficient allocation, will depend upon the extent to which the characteristics of the market "approximate those of the competitive paradigm" (Cummings and Nercissiantz, 1992).

Markets are ***predictable*** in the sense that resources are reallocated through transactions which occur in response to changes in supply and demand, but the flexibility sought through the market reduces future predictability. In the market the future prices in water transfers, and hence the equilibrium distribution of water rights, are by definition unknown. As a result, it is difficult, if not impossible, to anticipate how extensive the reallocation from one use to another might be. While water markets can be introduced without undue delays and this does not generally entail any major problems, it can be difficult and expensive, if not impossible, to reverse the situation - "the irreversibility of the market decision also has to be taken into account" (Kemper, 1996). If an undesirable situation arises, the government would have either to buy back the rights, a complex and prohibitively expensive undertaking, or to expropriate them, which is likely to be politically unfeasible and, if accomplished, has the potential to undermine investors' confidence in the economy.

Water resources management should be actively adaptive, i.e., it should seek to learn from experiences. If surprise outcomes are expected, initial market trading should probably be conducted at a scale and under regulatory supervision to minimize the chance of irreversible, adverse outcomes (Young, 1997). On this view, a slow evolutionary process can be an advantage rather than a disadvantage. The initial steps should obviously be consistent with the final design of the system. "Starting small gives both the institutions and the parties a chance to adjust and to become familiar with the system. Since most initial efforts will be precedent setting, it will take time to work them out. Once the precedents have been established, however, the process will become smoother, quicker and better able to handle a larger number of participants ... and trades" (Tietenberg, 1995). The experience in Chile suggests, however, that by their nature water markets may evolve very slowly and this concern may not, therefore, translate into reality.

Market transactions are ***fair*** in the sense that water reallocation takes place through voluntary mutually beneficial trades with perceived advantages for all the parties involved; each party must be made better off or one would refrain from trading. Markets can guarantee fairness only, however, if no single market participant can affect market prices. In addition, unless conducted in an institutional framework which causes market participants to take into account third party impacts, markets generally cannot guarantee fairness to third parties who may be negatively affected by market transactions.

Since the future prices in water transfers and the equilibrium allocation are unknown when a decision is made to introduce water rights transferability, the distributional implications cannot be known beforehand. On the whole, there is no particular reason to expect that a water market will necessarily result in an ***equitable*** allocation of water resources or change income distribution in any particular way. If equity and other important ***collective, public or social values*** related to water use are an important part of water policies, it may be necessary to opt for some governmental regulation. These concerns can usually be accommodated within the logic of the market system, for example, by purchasing water rights or reserving them in the initial allocation of rights. On the other hand, concerns about equity should probably be treated outside the market, though ultimately and in the long-run they are interrelated. The problem is income distribution, not the mechanism for water allocation. On the whole, water marketing is unlikely to create "new problems of unequal or unfair distribution beyond the reach of government policy" (Scott and Coustalin, 1995).

Finally, although theoretically some goals for water allocation, such as predictability, equity and fairness, and the need to reflect collective, public or social values, might be better served by non-market institutions, the existence of these problems "does not necessary call for a non-market alternative" (Anderson, Terry, 1982), because "market 'failure' in some abstract sense does not mean that a nonmarket alternative will not also fail in the same or in some other abstract sense" (Castle, 1965), hence the relevant comparison is between imperfect market solutions and imperfect administrative or political solutions, rather than between imperfect market solutions and the mirage of idealized administrative solutions.

D. Experience with water markets

The benefits of marketable water rights are not an illusion, they are confirmed by many empirical, semi-empirical, and theoretical studies. Studies conducted in various countries have estimated economic losses resulting from being unable to bring about market-based reallocation of water from lower to higher value uses. These losses, or unrealized benefits of water marketing, "represent the opportunity cost of failing to modify existing water institutions in ways which will promote more economically efficient use of scarce ... water supplies" (Vaux, 1986). More significant evidence on the benefits of market allocation is provided, however, from empirical studies of water markets in Chile, Spain and the United States of America.

1. Water markets in Chile

The existence of secure property rights in water appears to have made a noticeable contribution to the overall growth in the value of Chile's agricultural production since 1980. The introduction of water markets coincided with a major increase in agricultural production and productivity. The increase occurred within an agriculture largely dependent on irrigation, with no significant increase in the area under irrigation. The influence of water markets, however, cannot be fully separated from the effects of economic stability and other economic reforms, especially trade liberalization and secure land rights. Trading does appear, however, to have succeeded in reducing the need for new hydraulic infrastructure and improving overall irrigation efficiency. Stronger property rights have also helped to consolidate the autonomy of water users organizations (Bauer, 1997). On the other hand, less than 5% of water rights were transferred over a 10 year period (Peña, 1996).

A study of market transfers of water rights in the Elqui and Limarí in northern Chile showssubstantial economic gains from trade (Hearne and Easter, 1995). These gains occur both in intersectoral trades and in trades between farmers. Economic gains from trade are relatively modest in intersectoral trade in the Elqui river basin because water is being transferred from profitable farmers to urban drinking water supply, so that even though the financial gain to the seller is large, the economic gains of the reallocation are relatively small because if water is not used by its owner, it will be used by other farmers downstream (see Table 2). In the Limarí river basin, average gross and net gains from trade are estimated at US$ 2.47 and US$ 2.40 per each cubic meter per year transferred, respectively.

Table 2

Gains from trade in the Elqui Valley, Chile

	Number of shares traded	Gains from trade (US$ per share)	
		Gross	Net of transaction costs
Trades with the water utility	298	675	658
Other intersectoral trades	63	1 160	1 139
Intra-agricultural trades	351	934	839
Total/average	712	846	790

Source: Hearne and Easter (1995).

2. Water trading in the Huerta of Alicante, Spain

In the Huerta of Alicante, as in Chile, the ownership of water is separate from the ownership of land. Water is distributed by rotation at a fixed rate, approximately the same quality of water in each successive rotation, and the proportion of water available to any water right holder varies for each rotation depending on the water rights acquired on each occasion (Maass and Anderson, 1978). Before each rotation a notice is posted that announces the date on which the rotation will commence and informs water rights holders that they should within a prescribed period claim their "*albalaes*" or tickets for this rotation. Once allocated, tickets, available in twelve denominations for a constant supply of water from 1 hour to 1/3 minute, are freely

tradable in a public auction and an informal market. The community makes a genuine effort to provide farmers with information so they can buy and sell water intelligently and there are brokers who facilitate trading. A simulation model comparison of this system with those found elsewhere in Spain, where trading is not permitted, indicates that the market approach adopted in Alicante is the most efficient in terms of net increases in regional income. The differences are not great with only a moderate water shortages, but are significant in conditions of severe water shortage.

A comparison of several different short-run operating procedures, including the marketing of water rights, for distributing irrigation water in terms of their impact on net increases in regional income in Spain, using a composite of conditions in Murcia and Valencia, and in the United States, using a composite of conditions in Colorado and Utah, indicated that of the procedures that do not depend on full seasonal storage, markets and priorities by type of crop are the most efficient (Maass and Anderson, 1978). The latter procedure, however, is very inequitable and has been used only as a short-term response in severe droughts, while a market procedure ranks high in equity. The results show that markets are the most efficient of all the stream flow procedures considered, and that the conventional wisdom that the procedures "that rank high in efficiency will do poorly in distributing income equally among beneficiaries while those that do well in distributive equality will be inefficient ... does not apply to a wide variety of conditions in irrigation agriculture" (Maass and Anderson, 1978).

3. Water markets in the United States

Water markers are functioning in many western states of the United States. A comparative study of water markets in the states of Arizona, California, Colorado, Nevada, New Mexico, and Utah demonstrated that: (i) these markets are an important water allocation mechanism in many areas and are likely to become more widespread; (ii) they appear to be relatively efficient in allocating water among uses recognized as beneficial in state water codes with transfer patterns clearly indicating a movement from lower to higher-value uses; (iii) third party effects involving consumptive water users, i.e., return flow externalities, are generally reflected in market decisions and prices, but not so instream flow, water quality and other values that are not represented in water rights; and (iv) water markets typically deviate substantially from the competitive market model (see Table 3), and observed market prices may serve as only a rough approximation of the social value of additional water supplies (Saliba and Bush, 1987; Saliba, 1987; Saliba *et al.*, 1987).

Studies of individual systems show similarly favourable results in efficiency. The irrigation water rental market in the Northern Colorado Water Conservancy District and five major irrigation companies in the South Platte basin has resulted in substantial efficiencies and allowed the avoidance of considerable losses in crop production (Anderson, 1961). It has also reduced the waste that occurs when water users become involved in costly, time-consuming legal conflicts. The rules and customs developed for water transfers "make possible a better adjustment of the land-water relationship than is normally found in western irrigated agriculture. They might well serve as examples for other areas in adjusting for the varying needs of water users" (Anderson, 1961).

A review of two decades of market activity in the Lower Rio Grande Valley of Texas found active water marketing practices with significant volumes of agricultural water having been transferred to municipal and industrial use (Chang and Griffin, 1992). Analysis of representative market transactions indicated that municipal benefits from water marketing far exceeded agricultural opportunity costs. The study estimates municipal benefits from trades at about US$ 5 000 to US$ 17 000 per 1 000 cubic meters compared with the lost water values to irrigators which range from US$ 249 to US$ 1 894 per 1 000 cubic meters under optimistic agricultural circumstances.

Table 3

Restrictions in water markets

Restrictions	Effects	Restrictions	Effects
Imperfect competition and market restrictions	Market participants or public agencies restrict price levels and other conditions of market transfer, and observed prices may reflect these restrictions.	Uncertainty	Uncertainty regarding future water supplies, demand, and the legal framework that governs water transfers will affect market decisions and observed prices.
External effects of market activities	Market prices do not take into account the values of parties external to the price negotiation process or impacts of transfers on third-parties.	Equity and conflict resolution	Economic and legal barriers to market participation can create inequitable access to water. Water allocation decisions may serve as a form of conflict resolution and be made on political rather than economic grounds. Market prices may not fully reflect these considerations.

Source: Saliba *et al.* (1987).

A study of four irrigation companies in Utah found considerable gains from increasing the area in which trading was permitted (Gardner and Fullerton, 1968). Before 1948, only intracompany trading of water was permitted. In 1948, it became possible to transfer water between companies as well as within each company. Allowing intercompany transfers of irrigation water increased rental prices - reflecting the value of marginal product associated with the years before and after the change to an intercompany transfer policy in 1948 - three times (at constant market prices) between 1934-1941 and 1950-1964.

In 1991, California was in the midst of its fifth consecutive year of drought and the major water facilities were forced to significantly reduce water deliveries. In response to this emergency, the state government directed the Department of Water Resources to establish and operate a temporary Drought Emergency Water Bank to centralize the reallocation of water from sellers to buyers with critical needs on a short-term basis (see Box 2). The bank, in both physical and financial terms, generated the largest annual set of regional water trades to occur until that time in the United States and possibly in the world (Howitt, 1994). It helped alleviate extreme drought conditions across California. The net financial benefits of its operations were estimated at US$ 105.82 million. Water marketing also had a positive effect on employment resulting in the net state-wide gain of 3 741 jobs. The water bank was set-up again in 1992, 1994 and 1995 but on a smaller scale, and is expected to be implemented in the event of future droughts.

Box 2

The 1991 Drought Water Bank in California

Buyer participation was open to corporations, mutual water companies, and public agencies, except the Department of Water Resources (DWR). Buyers were required to meet rigorous criteria to qualify as having critical needs. Sellers were assured that transfers would not affect the standing of their water rights and would not be a basis for any loss or forfeiture of these rights, and that transfers would constitute a beneficial use of water and would not constitute evidence of waste or unreasonable use. To motivate early sales, purchase contracts contained a price escalator clause, that provided that if, by a specified date, the average price in similar transactions exceeded the prices in the contract by 10%, the seller would be entitled to the higher of the two prices.

The DWR set up a Water Purchase Committee, comprised of representatives from potential water purchasers, to negotiate the terms and conditions of a model contract for buying water. The committee and government agencies at all levels worked with the DWR to negotiate contracts, provide centralized control of water transfers, and coordinate distribution. When the water purchase contract was developed, participants anticipated that demands would exceed available supplies. Priorities were established, therefore, to assure that the most urgent needs were satisfied first.

Since at the start of the banking programme purchases focused on water from fallowed farmland, the initial purchasing price - about US$ 0.10 per cubic meter - was set so as to provide a net income to the farmers similar to what they would have earned from farming plus an additional amount to encourage them to enter into a contract with the bank. Once trading intensified, it proved difficult to change this price. As a result, the bank paid the same prices for water from all sellers. The price was considerably reduced when water supply and demand conditions improved.

The 1991 bank bought over 1.0 billion cubic meters of water through 348 contracts for approximately US$ 100 million. The bank charged about 0.14 US$/m³ for water delivered at the State Water Project's Sacramento-San Joaquin Delta pumping plant. This price covered: the purchase price, the costs involved in satisfying outflow requirements to move the water through the Delta (this reduced the net amount of water available for delivery), and administrative, monitoring and enforcement costs. The bank sold about 480 million cubic meters of water to 12 purchasers, some 80% was for municipal and industrial uses, and the rest for agriculture. The Metropolitan Water District of Southern California, serving the city of Los Angeles, bought over half the water.

The fact that water was bought from many sources required substantial coordination to match storage and delivery operations with available supplies. To minimize alterations in the operation of conveyance and storage system operations and maximize direct delivery of water bank supplies as they became available, water from the various sources was pooled and retained in the conveyance and storage system until the most opportune time for delivery. Considerable efforts were made to minimize negative environmental impacts.

On the whole, particularly given the crisis nature of the programme, the bank was an overall success. It provided an effective regulated market which reallocated water to users with critical needs at minimum cost. It succeeded in moving California from a condition of drought emergency to one in which all critical needs were met. Negative economic effects were minimal, and overall the bank generated substantial gains for California's agriculture and economy. Bank operations also provided some benefits to fish and wildlife.

Important lessons of the generally successful experience with water banking in California are that: (i) water banks can substantially reduce transaction costs and risks; (ii) the actual quantity of water reallocated through the programme was small in relation to the total use, but the price charged for this water set a value for all water which had a potential for being transferred; (iii) both water demand and supply were more price elastic than had been estimated before establishment of the bank; (iv) the number of buyers was much lower than the number of sellers, but the fixing of prices removed any potential monopoly power that the buyers may have had; and (v) water markets do not inherently require long lead times to put into operation.

Source: California Department of Water Resources (1991), Frederick (1993), Howitt (1994) and (1997), Israel and Lund (1995), McCarthy (1996), Thompson (1992), U.S. Office of Technology Assessment (1993), and Water Facts Group (1996).

II. Designing a water market

The decision to introduce a system of tradeable water rights requires the consideration of may issues so that the water market can function smoothly and equitably. One of the most important questions is the initial allocation of rights involving both the consideration of the acquired rights of existing water users and of the need to limit any windfall gains. It is necessary to ensure that once allocated the right is clearly and securely defined and appropriately registered. The establishment of individual rights must not come at the expense of society as a whole. Whatever decisions are taken and policies adopted the system must be as simple as possible, rights and obligations clearly defined and the intervention of government kept to a minimum.

A. The initial allocation of water rights

The introduction of a tradable water rights system requires the prior determination of the total number of water rights to be allocated and of the method of their distribution. The approach taken in the initial allocation can have a substantial impact upon the implementation and efficiency of the subsequent use of water marketing as the main means for water allocation. The magnitude of the political opposition to policy changes is usually proportional to the magnitude of any uncompensated redistribution associated with that policy. How rights are allocated is crucial to the acceptance or rejection of a water market by different groups of water users, "schemes which are elegant in an economic, engineering, or administrative sense but politically unacceptable can not be seriously considered" (David *et al.*, 1980).

1. Principal issues

A powerful theoretical feature of water marketing in a setting with many buyers and sellers, full information, zero transaction costs and other stringent assumptions, is that the final allocation of water rights will be the same regardless of their initial distribution. On this view, the initial allocation of water rights does not make any difference, except for equity considerations, for as long as there are markets where the rights are freely transferable the equilibrium allocation will be the same. At least in theory, this "implies that under the right conditions the initial allocation can be used to pursue distributional goals without interfering with cost-effectiveness" (Tietenberg, 1995).

In the presence of significant transaction costs, however, when information, bargaining, contracting and enforcement are not costless, and where there is market power or resource immobility, the initial distribution of water rights can and does affect the efficiency with which a water market will reach equilibrium. The initial distribution of water rights can matter to the quantity of transactions, the equilibrium allocation of rights, and the aggregate benefits of water marketing. If transaction costs are sufficiently large to preclude trade, the initial resource allocation will be retained as the equilibrium solution (Randall, 1983). These considerations suggest that there is a trade-off between promoting efficiency and equity considerations in the initial distribution of water rights.

Alternative initial assignments of water rights among individual users, local governments, environmental protection agencies, ethnic groups, etc. will result in entirely different sets of bargaining relationships and different patterns of water use and transfers (Saliba, 1987). Market outcomes depend on the initial distribution of rights, as "a given distribution of endowments (rights) will give rise to one set of market outcomes, but a different distribution of endowments will give rise to a different set of outcomes, and both sets of outcomes are considered ... efficient" and "there is no economic efficiency basis to compare the relative merits of" both outcomes (Chan, 1995).

Markets reallocate water rights through voluntary transfers between willing buyers and sellers, but the distributional impacts of market transactions - how the scarcity rents from water are distributed, who has the protection of the State to use water as they wish, who must pay to obtain water rights, and who receives payments - depend on the initial allocation of water rights and bargaining power. It is the role of the political process to define the institutional regime which will determine the form of distribution of the rent and this choice should be made explicitly with both efficiency and equity (distributional) goals and constraints in mind (Bowen, Moncur and Pollock, 1991).

Care needs to be taken to respect and not to affect the rights of disadvantaged groups, such as poor farmers and indigenous peoples. There is a need to draw attention to the proposed system for the distribution and recognition of existing of rights through campaigns of public information, as well as to offer legal and technical advice and to provide assistance to disadvantaged groups. In Chile, for example, the government has a programme to facilitate the legalization of the property titles to water rights; it has been spending more than US$ 0.32 million annually for this purpose (Ríos and Quiroz, 1995).

One issue which must be addressed in the initial policy process is the possibility of large and questionable windfall gains that might accrue to water users, who obtained water from publicly funded infrastructure developments, and whether the government should try to recover the capital costs of historical public investment in water-related infrastructure. Various solutions have been proposed to deal with such undesirable windfalls. These range from outright prohibitions of transfers and other restrictions on trading, which if adopted are likely to result in inefficient resource allocation and stifle incentives to transfer and conserve water resources, to allowing transfers without any restrictions, which will facilitate the reallocation of water to higher value uses, but at the expense of windfall gains to original users. Intermediate positions include the imposition of a windfall tax, dividing the windfall according to a formula which encourages transfers and yet permits the government to share in it (Gould, 1989), and greater reliance on alternative mechanisms for initial allocation, such as auctions. Whatever the approach adopted, it should not render inoperable the vital mechanism that encourages efficiency through market transfers - water users need a financial inventive to participate in water marketing. Subsidies and other public policies, which affect returns to water, distort water use and transfer decisions by allowing their beneficiaries to ignore the real cost of their water. The removal of subsidies should both increase the quantity of water rights users are willing to trade and reduce prices.

In the initial allocation of water rights, consideration should be given to establishing minimum flows to protect aquatic and riparian habitats, and other uses which, because of strong public goods characteristics, cannot compete in the market for water. Where an initial allocation of water rights for minimum flow maintenance is not possible because historic uses have preempted the total supply, an argument can be made for a one time reallocation of

water rights from current offstream uses to instream use as a means of redressing past policy deficiencies which resulted in over-allocation to offstream uses (Griffin and Boadu, 1992). In Chile, although no provision of this kind is included in the law, new water rights can be granted only if this does not affect the rights of third parties and, in recent years, the interpretation of the rights of third parties has been expanded to include environmental protection and ecological flows (Peña, 1996).

A similar argument can be constructed for a one-timer reapportionment of water in favour of any disadvantaged groups as a means of redressing past policy deficiencies. If a decision is made to undertake such a realignment, it is particularly important to assure water users that the government will be reluctant to intervene in the future, because "further threat of intervention can only undermine decentralized policies and encourage unproductive expropriative effort and defensive action" (Griffin and Boadu, 1992). An alternative would be for the government to enter the market to acquire water rights for the desired purpose.

2. Alternative procedures

In introducing a water market where administrative allocation has been the system previously applied, a government may choose one of two main ways to distribute water rights to water users. Water users could be granted water rights free of charge based on some regulatory distribution rule, usually the historic record of possession of permits for water use existing under the old system, "grandfathering", or, where such evidence is lacking, according to other benchmarks, such as land holdings. The second alternative would be for the government to sell water rights. The sale, to be equitable and to be able to match supply and demand, would have to be through auctions as the valuation of the water rights is unknown. A combination of these two approaches can also be used, such as allocating a proportion of the previously recognized water rights free of charge on the basis of historic use and the rest by auction. Leasing is possible but less attractive because it is likely to fail to provide a high level of security to holders and to reduce post-allocation investment.

Although basing the initial allocation of water rights on historic water use is the easiest and the most commonly used system, governments could achieve greater efficiency gains from the system by auctioning all rights to the highest bidder, but this alternative presents potentially high political costs. Grandfathering represents effectively a transfer of wealth to existing water users. Auctions ensure that the wealth represented by water rights is transferred to the society as a whole and windfalls are avoided. "The auction solution would give some concrete meaning to the vague proposition, so much a part of current water law, that the unappropriated waters ... belong to 'the public'. An auction would enable the public to realize on that purported ownership - now a matter of rhetoric - in the form of receipts flowing into the state treasury" (Williams, 1983). Existing users prefer grandfathering to auctions because by preserving the status quo, it can serve as a barrier for the entry of new users, thus raising existing users' profits. On the other hand, it can be argued that because the ability to transfer water rights provides a new asset to holders, it is reasonable for the government to be able to sell at least some of the rights.

Selection of the procedure for initial allocation raises a number of other equity questions: (i) whether equity should only apply to exiting water users, in which case the free initial distribution approach becomes more attractive (there is also a question of equity between existing and future water users, which at least in theory can be partially resolved by reserving some rights for new users), or to all citizens, in which case sales of water rights to users might

be acceptable if the revenues go into the general revenue fund; (ii) whether water users should have to pay for water rights at all; and (iii) whether and how environmental and other instream interests can enter the allocation procedures (Lyon, 1982).

With auctions, water rights will tend to go to those to whom they are most valuable, hence an auction promotes efficiency, although this will depend on the detailed design of the auction. Under grandfathering, in contrast, water rights remain in their historic uses which are not necessarily those with the highest value, while new users must purchase rights in the market. Grandfathering imposes extra costs on new users, preserves inefficient patters of water use, as well as reduces the rate of entry of new users and hence retards rather then promotes technological change. On the other hand, by providing an asset to an existing water user wishing to sell, it could conceivably facilitate adjustment and resource mobility.

Grandfathering also provides ample opportunity for administrative discretion and strategic manipulation unless the allocation is based upon information that is extremely difficult to manipulate, and hence invites lobbying efforts to protect vested interests and maintain the status quo and may give perverse incentives to existing rights holders. For instance, anticipation of grandfathering could encourage users to expand their withdrawals in order to qualify for more water rights. If regulators do not act to prevent such strategic behaviour, the system can reward the least efficient users. In contrast, auctions not only prevent such negative consequences and mitigate the appearance of favouritism or secret negotiations, but also remove the incentive for the water users and other interest groups to engage in rent-seeking activities which waste resources. Auctions also readily identify appropriate prices and make the value of water more explicit at the moment of introducing a market.

Grandfathering tends to place a large proportion of water rights in the hands of largest water users. This may be a particular problem with public utilities. Allocating a large share of the available water supply to colluding users can lead to the problem of imperfect competition and market power. By subsequently restricting the supply of rights to the market, these users could exercise market power, while at the same time erecting a barrier to the entry of new users, who, having to pay a premium to acquire the necessary rights would begin at a competitive disadvantage (Bertram, 1992).

Auctions may, however, provide only a partial solution to these difficulties. Since bidders will make offers subject to their budget constraints, which "are the key to bidding strength, access to finance would be a powerful factor in determining the identities of successful bidders" (Bertram, 1992). Thus, a bidder or group of bidders with financial advantage not being related to the ability to put water to highest value use could conceivably gain a large share of the initially auctioned water rights, and by subsequently restricting the supply of rights to the secondary market, could exercise market power.

Finally, the main advantage of grandfathering is that it avoids conflicts and reduces the opposition of existing water users, typically farmers, to the introduction of a market. Farmers usually argue, and not without reason, that they are entitled to receive water rights without charge because they have already paid for the rights implicitly in the purchase price of the land. With the assignment of rights on the basis of historical use, there is no financial burden from the payment for water rights, the fact that may explain at least in part why the auction approach has not been widely adopted. Under the auction approach, although payments for rights do not represent real economic costs to society as a whole, but merely transfers from one group to another, to the users, they constitute a financial burden.

In practice, most countries have recognized existing water uses at the time of assignment of property rights to water to protect existing uses and to prevent opposition to the policy change. There may be, however, some merit in trying to, at least partly, rectify some of the deficiencies in the existing distribution of water rights, but there are obvious limits to the ability and willingness of any government to do this because "if the government were to try to use this opportunity to correct all such mistakes or to confiscate all illegally obtained rights, there is a good chance that the law will be blocked and the injustices continue" (Thobani, 1997).

Auctioning water rights to the highest bidder has many attractive characteristics, but it has difficulties of its own, including the lack of familiarity with auctions among potential buyers, the danger that bidding for water rights may fail to be competitive, etc. Auctions can also bring problems of a "public choice" nature, i.e., the ability and willingness of the public sector to organize and conduct auctions with efficient and equitable outcomes (Bowen, Moncur and Pollock, 1991). Potential issues include the equal treatment of public and private water users, the influence of special interest groups, and the fact that the need to raise additional revenues can lead the government to over-allocate water rights or to allow their concentration in the hands of few users. For this reason, it is preferable that the agency that determines the volume of water rights to be allocated should not stand to profit from an increase in their number.

If public authorities are concerned not only with economic efficiency, but also with equity effects or regional economic development, it is important to ensure that the use of auctions does not conflict with such goals. Public policy objectives other than revenue maximization, such as protecting existing or implied rights to the resource, can be addressed through appropriate design of the auction process (Morgan, 1995). This protection can take various forms, such as reserving some water rights for designated bidders, allowing them to pay in instalments, and using price preferences to facilitate the acquisition of rights by designated bidders. In theory at least, price preferences should not materially affect total revenues because non-designated bidders will face greater competition, and, therefore, pay higher prices.

3. National experiences in the initial allocation of rights

When market allocation of water has been introduced, the initial allocation of rights has almost always been based on the recognition of the formal and informal water use permits or licenses already held. Future efficiency in water use and allocation is *per se* ensured by the transferability of rights. Under grandfathering, therefore, an efficient secondary market is essential to fulfil the dual role of correcting the inefficiencies inherent in the initial allocation process and to provide a mechanism for the allocation to adjust to changing supply and demand conditions in the longer term (Morgan, 1995).

Where there is a well-functioning registry of water rights and where there is sufficient water to honour all water rights, it is usually sufficient to recognize all existing rights once water users reregister them in a property rights register (Holden and Thobani, 1995). If the volume of water rights exceeds available supply, rights would have to be assigned on the basis of historic use, need - the complications that can arise are well illustrated by the apparently simple solution adopted in Colorado (Box 3), land area, or according to other benchmarks.

Box 3

The allocation of supplemental water supplies in the Northern Colorado Water Conservancy District

The completion of the Colorado-Big Thompson project, in 1957, made available the new water supplies to the Northern Colorado Water Conservancy District. The District decided to allocate the new water rights on the basis of the future users' needs and possibilities of putting the water to beneficial use.

Users were asked to present applications which were processed in the order in which they were received. Since the number of applications exceeded the amount of the water rights available for allocation, latecomers were placed on a waiting list, and their applications were considered as other users declined their initial allocation.The allocation of water rights was based on an analysis by the District of how much supplemental water the applicant would be able to put to beneficial use. In the case of farmers, the main criteria used in the analysis were the soil type, the historical cropping pattern, and the already existing water supply. The process included visits to the applicants' farms and physical inspections.

Although water rights were allocated free of charge, the beneficiaries had to place a lien on their property against a repayment obligation to the federal government (the project was financed with a long-term government loan). The risk of lien constituted an implicit price and some users decided not to participate in the allocation process for fear of losing their properties if the District failed to meet its payment obligations. To cover the repayment obligation and operating expenses, all water rights holders pay an annual assessment based on the number of rights owned.

Linking the allocation of water to the repayment of the project debt favoured relatively wealthy applicants, because only those who were able and willing to put up their property as collateral could participate in the allocation.

Source: Cestti and Kemper (1995).

Allocating water rights on the basis of existing land rights might work fairly well where the distribution of land is reasonably equitable (Easter and Feder, 1996). If land ownership is highly concentrated or perceived as inequitable, an alternative water allocation criteria would be needed. For example, water rights could be allocated to all families, both landowners and landless, in the irrigated area so that all share directly in the economic surplus created by the reform (Easter and Hearne, 1995).

In Chile, at the time of the promulgation of the 1981 Water Code which reintroduced and amplified private property rights in water, the initial allocation of water rights was based on the water rights held prior to their nationalization under the agrarian reform. These rights could be overridden, however, in favour of those who had been making "effective" use of the right for the five years prior to the promulgation of the law. The availability of relatively good records held by user associations facilitated the allocation process and made it possible to honour the historic allocation (Cestti and Kemper, 1995). It is estimated, however, that even now somewhere between 50 to 65% of water rights are not legally registered (Ríos and Quiroz, 1995). The most important reasons for this are that all rights are noted in the books of water user associations and rights are not lost through failure to register. This removes any real incentive to register the rights unless someone wishes to sell. Water rights were, and still are, assigned to the applicant without charge and without any obligation that the water be put to any use. The Dirección General de Aguas (DGA) must grant requests for new rights whenever there is water physically available and the rights of third parties are not affected. It has no administrative discretion to decide among competing solicitants except by holding auctions.

Other countries have also adopted the grandfathering approach. In Mexico, water rights are allocated on the basis of the formal and informal water rights already held (Holden and Thobani, 1995). Many rights remain unregistered due to the complex and slow registration procedures, unwillingness on the part of informal users to regularize their situation because of fears of fines, the fact that users often do not have the documents required for registration, users apply for larger volumes of water than they are entitled to, and others claim that they cannot afford or are not willing to pay fines and registration fees (World Bank, 1996).

There are examples of the use of auctions for the allocation of water rights not allocated in an initial allocation process or made available as a result of new publicly-funded infrastructure development (Box 4). In Chile, auctions can be used for assigning rights, and must be used where there are two or more simultaneous applications for rights over the same water, as well as, for unclaimed rights made available as a result of publicly financed infrastructure projects. In practice, few have been held (El Diario, 1996). In Peru, a similar approach has been proposed in the draft water law which provides that rights to new or unallocated water are to be allocated via public auction (Holden and Thobani, 1995). Auctioning would begin based on a minimum price and if only one party is interested in the right, it will be awarded at this price (World Bank, 1994).

B. Permanent versus time-limited water rights

Water rights can be permanent or time limited. Theoretically, as long as the rights are freely transferable, either option is acceptable, because their transferability will permit rights to be reallocated to higher-value uses in response to changing economic and social conditions. The choice of duration of the right, however, determines how easy it is to organize a market, at what level of transaction costs it will operate, and perhaps more important, the nature of incentives water users will face to invest in the development and conservation of water resources.

Permanent water rights are often preferred for two principal reasons. On the one hand, the homogeneous nature of rights, i.e., all rights are of the same duration, simplifies market creation and reduces transaction costs. On the other hand, and perhaps more important, since protected rights to the use of water are a crucial element in promoting investment, a system of time-limited water rights is likely to fail to provide the necessary degree of security to promote long-term investment and planning, and protect the stability of long-term financial arrangements related to economic development which depend on secure access to water resources. It can also introduce legal and economic uncertainty in water resource management and can be difficult to implement because of the rigidity of the infrastructure already in place, to say nothing of the political difficulties of terminating rights. Every outstanding water right represents: (i) an established business that relies upon water; and (ii) many people, including employees, customers, backward- and forward-linked industries, etc., that depend upon the business. "To take away its water, and thus its chance to exist, would be wasteful and terribly unfair ... Quite a lot of people will be outraged if the agency pulls the rug out from under the old firm" (Williams, 1985).

Box 4

Auctions in the allocation of supplemental water supplies in the state of Victoria, Australia

The completion of a new dam made 35 000 megalitres of water available for allocation to water users in the form of 15-year diversion licences. A number of methods were considered to allocate the licences. The initial decision to require sealed bids was discarded because of strong resistance from farmers in favour of a more open auction process. Subsequently, during 1988 and early 1989, the Rural Water Commission of Victoria (RWC) sponsored six auctions. The auctions were perceived as an efficient and equitable mechanism to allocate limited water supplies to their highest value use.

The auction was qualified to facilitate the acquisition of licences by small farmers, prevent large farming companies from purchasing large quantities, and improve the public acceptability of the approach. This makes Victoria's experience particularly interesting to Latin American countries where small subsistence farmers often exist side-by-side with modern farming enterprises and large landowners.

The following rules were adopted:

- Participants had to complete a preregistration form indicating the maximum volume of water that they were interested in acquiring and its intended use.
- Participation was limited to private irrigators with legal access to the river from which the water was available and to land owners or lessees in the basin. Users in public irrigation districts and urban areas, and speculators were not eligible to participate in the auctions.
- A reserve price of $AUS 100 per megalitre was established but not disclosed at the auctions. It was based on a conservative estimation of the financial value of water in growing a relatively low value crop. The fact that the price underestimated the value of the water was attributed to the need to sustain interest in and ensure acceptance of the auction process.
- Purchases by any single land holding were limited to 10% of the volume being offered. Anyone with multiple land holdings could purchase more than the 10% limit.
- The volumes of water offered for sale were broken into "stages" or minimum purchases, e.g., Stage 1: 1 megalitres; Stage 2: 10 megalitres; ... Stage 7: 200 megalitres. Bidders were required to make at least the minimum purchase corresponding to the stage in which they participated. They could participate in several or all stages, but had to preregister to make at least the minimum purchase in a particular stage.
- Bidders competed on the basis of their willingness to pay for 1 megalitre. The highest bidder could purchase the volume of water desired at this price. Other bidders were allowed to purchase any remaining water at the same price. If they desired more water than what was available, bidding was reopened.

Of the 31 000 megalitres offered for sale, 23 000 megalitres were sold through auction. Prices varied from $AUS 775 per megalitre in the first auction, to $AUS 100 per megalitre in later auctions, with the bulk of the water purchased at the reserve price or slightly higher. Lower prices were paid for larger volumes of water, and higher prices for smaller volumes, usually bought for the production of high value crops. A quarter of the 200 successful bidders were new irrigators, about one-half of whom bought 20 megalitres or less. All the water offered in the first two auctions was sold, but not in the later auctions. As a result, eligibility was expanded to include users from other basins, in an effort to encourage competition and to "broaden the market", but water still remained unsold. Demand and prices declined as more auctions took place. The reserve price become known before the later auctions were held and bidders became unwilling to bid higher that this amount.

The effect of the restrictions in the auction was an improvement in equity but at the expense of introducing a degree of inefficiency. Competition was constrained, the chances of transferring greater volumes to higher value uses were reduced, the benefits for public finance were limited, and it was not possible to extract all of the gains from trade.

Source: Simon and Anderson (1990) and Cestti and Kemper (1995).

Property rights in water in most markets have, therefore, perpetual duration, as for example in Chile and the western United States, although, given the rules of abandonment and forfeiture for non-use, in the later case they can be more precisely described as "of indefinite duration" (Trelease, 1974). It has been argued, however, that a system of time-limited water rights can have its attractions.

First, to the extent that water rights may be initially granted on the basis of historic use ("grandfathering"), the negative effects associated with this method of initial allocation would be mitigated under a system of time-limited rights. Specifically, time-limited rights could both reduce the risk of large water users gaining market power and the need for regulation to ensure that such market imperfections are avoided. The limited duration of rights implies that an alternative allocation methods can be established when the present rights expire (David *et al.*, 1980).

Second, potential future water management policy changes (e.g., the introduction of minimum or ecological flow requirements, changing political and social values regarding alternative water uses, the potential effects of permanent or very long-term rights on the sustainability of the resource given uncertainties in scientific understanding of the extent of the resources, etc.) could be accommodated more easily, perhaps, under a system of time-limited rights. Permanent rights or rights of very long duration promote investments and allow long-term planning by holders, and thus encourage economically efficient decisions. They are, however, expensive, if not impossible, to recapture by the government whereas short-term rights may simply not be reissued when they expire (Eheart and Lyon, 1983). Once permanent rights are granted it is very difficult to reverse the situation created, particularly when the capacity to impose *ex post* conditions is limited.

Any potential administrative flexibility offered by time-limited rights comes, however, at the expense of a corresponding increase in uncertainty for the water right holder. Water markets depend on secure ownership rights. If a system of time-limited water rights is used, rights would have to be of sufficient duration to provide reasonable security to holders, to allow sufficient time to amortize capital investment and, also, to provide adequate incentives to invest. Very short term rights not only discourage long-term investments and planning, and increase uncertainty, but can also create tension between public authorities and water rights holders, heighten conflict rather than cooperation amongst water users, exacerbate the uncertainties of the regulatory playing field, and most fundamentally, make financing long-term capital investment very risky and costly (Vogel, 1997).

In the same way, attempts to impose *ex post* conditionalities on permanent rights to accommodate changing economic and social demands and conditions, if not implemented carefully, have the potential to generate uncertainty and undermine the market. With rights of sufficient duration, a system of fixed-term rights can strike a balance between the need to provide security to investors and the need to provide flexibility by making the rights subject to periodic review. Very long terms, however, would probably turn into permanent rights.

One option to address the trade-off between uncertainty and flexibility is to issue water rights in a staggered patters over *n* years such that one *n*th of the rights expire in any given year (Eheart and Lyon, 1983). It has also been proposed to issue water rights with different durations. Water users undertaking water-related investments with long payback periods and willing to pay for the security that long-term water rights afford would be able to hedge against the risks of future policy changes by buying water rights for longer periods. Both approaches,

perhaps particularly the second, share a disadvantage stemming from the heterogeneous nature of rights with different durations which could make it difficult to organize the market and increase transaction costs.

If a right is to have time limitations, this must be clearly defined as a part of the right (Simpson, 1994a). In addition, if the market is to allocate water rights efficiently, the duration of rights should not be subject to any particular actions on the part of the user (Eheart and Lyon, 1983). It should be recognized that limitations on the term of water rights, their renewability as well as other restrictions on the type of use that can be made of them lessen their value for the water users and discourage transfers.

Time-limited water rights are used in Mexico, where, under the "Ley de Aguas Nacionales" of 1 December 1992, the utilization of water resources is through "concessions" granted to private individuals or corporations, and "assignments" granted to federal, state and municipal entities. Concessions and assignments can be granted for renewable periods of from 5 to 50 years. The average term has been more than 30 years to ensure security of the water right (Rosegrant and Gazmuri, 1994).

C. Hydrological security and allocation rules

The fact that any water supply is variable in time and space affects the hydrological security of water rights, which in turn affects their market value. It is for this reason that water rights that draw on water resources characterized by low variability, such as high-volume perennial streams, groundwater aquifers or large lakes and reservoirs with known and steady average inflow are more valuable than the rights drawing on highly variable resources or where supplies cannot be accurately estimated. Changes in the hydrologic capacity of the water resource can cause the yield of a particular water right to diverge from the full limit of the right. For this reason, water rights holders are concerned with the allocation rules which relate available water supplies to individual users' permitted withdrawals or consumption, and hence determine the reliability of the nominal quantity specified in the water right.

Risk management and reallocation is one of the dominant motivations for water transfers which are viewed by many water users as a means of acquiring more protection against hydrological variability than their current water rights holdings provide. For instance, one of the most typical market transactions is the purchase of irrigation rights by water utilities which seek to protect current and future customers against supply fluctuations. Other water users who pay close attention to security of supply include industrial water providers and farmers with orchards and other permanent crops.

Allocation rules are the institutional response to the need to make water rights relatively secure. The way in which allocation rules are defined determines how easy it is to organize a market for transferable water rights and how the risks associated with water shortages are shared among rights holders (Colby, 1988). While there are many ways to allocate water supplies, the major alternatives are priority allocation and proportional rules. Water right systems often combine elements of both methods.

Under a priority rule, water rights are defined in terms of two parameters, size and priority. Priorities may be determined in terms of time of use, type of use, for example, drinking water supply versus irrigation, or location (Easter and Tsur, 1995). Type of use and location priorities are difficult to reconcile with flexibility in water allocation and the transferability of water

rights. The most common priority rule is that reflected in the prior appropriation doctrine of the western United States which operates on the "first in time, first in right" principle. Under the prior appropriation doctrine, in times of water shortage, senior rights holders are satisfied to the exclusion of junior rights holders with the latest appropriators being cut off in inverse historic order until demand equals supply. Since priority date affects the number of days and seasons of the year during which water can be used, and hence determines the reliability of the right relative to other rights, rights with earlier priority dates usually command higher prices than rights with later priority dates (Colby, Crandall and Bush, 1993).

Under a proportional rule, water rights are defined in terms of a fraction of the available flow or of the water available in a reservoir or lake or in terms of shifts or hours of availability at a certain intake. All water rights holders have equal priority sharing available water based on the proportion of rights held. Thus, all water users drawing water from the same sources share the insecurity inherent in variable water supplies. In Chile, in the water law, rights are defined in volumetric terms, but in times of shortage, the law allows for water to be distributed proportionally to the number of rights held. In practice, however, the generally high variability of natural river flows and lack of significant storage capacity limit volumetric allocation. In consequence, water allocation is, in practice, usually on the basis of a share of stream flow. Rivers are divided into sections, and each withdrawal point receives a percentage of the water in the respective section. Much of the work of water users organizations involves measuring flows and allocating the water corresponding to each right.

A variation of the proportional system has been adopted in some localities in Australia where share holders in storage projects use the concept of capacity sharing to reduce uncertainty (Livingston, 1993). Water rights are defines as shares of reservoir storage space, and its inflows and losses. Decisions as to reservoir releases are left to water rights holders with balances being calculated continuously by deducting the amount of releases from storage shares, adding shares of inflows, and deducting estimated evaporation and seepage losses (Frederick, 1993). Water transfers are accomplished by simply making the appropriate debits and credits. Where adequate storage is available, capacity sharing simplifies water transfers and allows water users better control over the timing of water deliveries. "It is as if each user of water, or group of users, has their own small reservoir on their own small stream to manage independently from others" (Dudley, 1992).

Variations on these two basic methods for allocating water supplies can be found. One example under the prior appropriation system is afforded by irrigation projects, mutual water companies and other similar organizations which acquire water rights of various priorities and then use a proportional method to allocate available water supplies among their members who benefit from risk pooling. The water dividend to each user is not constant over time, but varies according to the stock held by each user and the available water supply.

Another example of a mixed approach is afforded by the distinction between permanent and contingent or eventual water rights in Chile. Permanent water rights are allocated up to the average flow of a river and they have the first claim on available water. Contingent rights are granted for surplus flow and they can be honoured only after all permanent rights have been satisfied, so they are less secure. The allocation of water among contingent rights holders is governed by a priority system according to the seniority of the rights. Since the use of contingent water rights it typically limited to winter and spring, when flows are higher and agricultural demand is low, they are mainly useful for water users who

have sufficient storage capacity to capture water during periods of abundant water supplies and preserve it until the summer growing season.

The manner in which allocation rules are defined may affect the efficiency of the water rights systems, but deciding which approach encourages the most efficient allocation "depends upon the specific characteristics of the water supply and users" (Eheart and Lyon, 1983). Theoretically, if a costless short-term water market were possible, there would be little or no difference between the systems and trades under either of them would tend to allow equivalent *ex post* outcomes to be attained (Howe, Schurmeier and Shaw, 1986b; Eheart and Lyon, 1983). Real short-term markets do, however, involve transaction costs and there can be other impediments to spot rights trades as well. As a result, in some cases, a priority rule may be preferred; in others, a proportional rule may be more efficient.

A priority rights system appears to have efficiency advantages in areas of mixed water use where water users are heterogeneous with regard to their demand functions and risk avoidance, while a proportional system appears to be advantageous in uniform systems where users' demand functions and risk avoidance are similar (Howe, Schurmeier and Shaw, 1986a and 1986b). Under a priority system, risk-sensitive water users can acquire more senior rights at higher prices, while those who are less sensitive to water shortages can acquire more junior rights at lower prices. Thus, market transactions allow the transfer of senior water rights to those economic activities which value reliable water supplies most. Water users can achieve the desired level of security and still hold water rights equal to the average amount needed. The inefficiencies that can arise during periods of shortage may be solved by short-term exchanges of rights among water users holding rights of different priorities (Howe, Alexander and Moses, 1982).

Under a proportional system, the fact that water users who need a reliable supply can reduce the probability of shortage only by holding water rights in excess of average needs may introduce some inefficiencies and encourage hoarding. Since during periods of normal supply their rights yield in excess of their normal use, they usually lease this excess water to other users on a seasonal basis. This phenomenon can be observed in Chile where many farmers hold on to what may seem "surplus" rights to assure themselves of secure water supplies in dry and drought years (Bauer, 1995b and 1997; Peña, 1997). In normal and wet years these "surplus" rights are either unused, benefitting other water users downstream, or leased, but they are usually not for sale. Since leasing is characterized by a higher risk of non-availability and greater uncertainty and risk, the application of leased water is likely to be limited to low-value uses (Howe, Schurmeier and Shaw, 1986a). The fact that this water is unlikely to be made available during periods of shortage can preclude its application to those economic activities which place the highest value on reliable water supplies. As a result, more water could end up in short-term leases and, therefore in lower-value uses, than under a priority system.

Another advantage claimed for a priority system is that, unlike a proportional system, it provides tenure certainty for each water right holder by protecting them against loss of their rights through the legal actions of others (Burness and Quirk, 1979). While under a proportional system, the appearance of a new claimant to water reduces the tenure certainty of existing water users, the seniority of the right protects the privileges of existing users under a priority system. Apart from political and social pressures to allocate more water rights than long-term historical flow can support, principal problems appear to be the lack of hydrological data and the fact that many water rights that must be honoured today were granted many

decades ago when understanding of the hydrological cycle and knowledge of the resource were much less sophisticated than today. For this and other reasons the long-term average yield of a water right under a non-priority system can be expected to be less than the maximum flow rate or volumetric limit of a water right. Under a priority system, rights of senior appropriates will be completely satisfied to the exclusion of junior appropriators.

A priority system of water allocation has, however, a major disadvantage stemming from the heterogeneous nature of priority rights which can make it difficult to organize the market and increase transaction costs. Under a proportional system, in contrast, the more homogeneous nature of the rights, which are essentially interchangeable even though the supply varies, facilitates market creation. This conclusion is confirmed by the experiences of Chile, and of the Northern Colorado Water Conservancy District, "probably the best example of a functioning water market" in the western United States (Cummings and Nercissiantz, 1992). In addition, a proportional system of allocation allows low cost risk sharing among homogenous water users. It is also operationally simpler and "more easily adaptable to formal market procedures" (Eheart and Lyon, 1983).

III. Transaction and transportation costs

The costs involved in the transfer of property, or transaction costs, and the costs of transporting water, can significantly affect the capacity of any market to operate efficiently. If water marketing is to achieve its full potential, markets must be designed to minimize these costs. Water marketing may lead, however, to efficiency gains, even if transaction and transportation costs are high. Moreover, increasing water scarcity raises gains from trade relative to these costs. Transaction and transportation costs can be lowered by technological advance and institutional investment and are also likely to fall somewhat as the level of trading increases, as there are often strong learning-by-doing effects.

A. Transaction costs

Transaction costs are the resources dedicated to establish, operate, and enforce a market system. They may take one of two forms, namely (i) the services which buyers or sellers must provide from their own resources; and (ii) the differences (margins) between the buying price and the selling price of a commodity, for example, due to the direct financial cost of brokerage services (Stavins, 1995). Transaction costs are born not only by the trading parties, but also by the public sector. These costs may be in whole or in part transferred back to trading parties through fees and taxes levied on water rights transfers.

There are three potential sources of transaction costs in a system of tradable water rights: (i) ***search and information*** costs, such as searching for trading partners, verifying ownership of water rights and describing the right for purposes of the proposed transfer; (ii) ***bargaining, contracting and decision*** costs, such as negotiating the price, arranging financing and other terms of transfer, drawing up contracts, consulting with lawyers and other experts, paying fees for brokerage, legal and insurance services, and transferring legal titles; and (iii) ***policing, monitoring and enforcement*** costs, such as setting up a legal, regulatory and institutional framework, mitigating possible third party effects, and ensuring compliance with applicable laws.

In a water market, a considerable proportion of transaction costs can arise not from the needs of the trading parties themselves, but from public policies governing water transfers. The burden that policy-induced transaction costs impose on trading parties arise not only from the direct costs associated with a transfer but also from time delays while waiting for regulatory approval of a transfer proposal and the risk that the proposed trade will fall through (in this case, trading parties lose the transaction costs they had expended in attempting to make the trade). These opportunity costs can be high. For example in the western United States, the delay from the time a transfer application is filed to the date of the state agency decision varies from 4-6 months in New Mexico, to 5-9 months in Utah, and to astonishing 20-29 months in Colorado (Colby, McGinnis and Rait, 1989; MacDonnell, 1990).

In Chile, the 1981 Water Code regulates the maximum time required for the resolution of conflicts arising from the acquisition or exercise of water rights taken to the DGA: 30 days for the public notice of a transfer to be published at the expense of the applicant, 30 days for third parties to protest the application, 5 days to transmit the protest to the applicant, 15 days for the applicant to reply to the protest, 30 days for the DGA to request additional information, 4

months for the DGA to rule on the transfer, 30 days for the applicant and protestants to present an appeal for reconsideration to the DGA which has 30 days to rule on it, and finally the applicant and protestant have 30 days to appeal the DGA's decision to the Appellate Court (appeals do not generally suspend the implementation of the DGA's resolution).

Most transaction costs found in water markets are present, of course, in one form or another in other systems of water allocation. In addition, there are reasons to believe that the transaction costs associated with water marketing will be lower that the administrative costs associated with other allocative mechanisms because they are largely borne by the private sector, which has greater incentives to control costs and because the market generates at least some of the necessary information (Holden and Thobani, 1995; Ríos and Quiroz, 1995). On the other hand, economies of scale could potentially reduce administrative costs in large centralized systems.

Transaction costs prevent markets from operating efficiently and reduce the overall economic benefits of water marketing both ***directly***, by absorbing resources allocated to transactions, and hence reduce the profitability of water transfers, affect the level of market activity, and debilitate incentive properties of water marketing; and ***indirectly***, by suppressing transactions - and hence reducing total trading volume - that otherwise would have been mutually and socially beneficial (Stavins, 1995). Transaction costs prevent the equalization of marginal water values among different uses, users and locations. These price differentials between and among uses, users and locations represent unrealized gains from trade, and hence inefficient allocation. Because transaction costs add to the costs of a market transfer, the potential benefits generally must be sufficiently large to justify the transaction costs associated with the proposed transfer and the risk that the trade will fall through. In extreme cases, transaction costs can prevent markets from forming altogether. The non-existence of certain markets is often explained as a rational market response to transaction costs in excess of potential gains from trade (Randall, 1983).

These considerations imply that transaction costs usually, but not always, reduce welfare and that public policies reducing them are welfare improving in so far as they facilitate wealth enhancing trade. On the other hand, some transaction costs arise from attempts to protect third-party interests: "transaction costs do represent relevant interests, or at least interests no less relevant than the typical non-transaction costs. Transaction costs represent the protection of interests through rights as they become valued through the market …" (Samuels, 1974). Policy-induced transaction costs are not necessarily wasteful or inefficient if they provide protection for third parties who may be affected by water transfers (Colby, 1988). To ensure that market transfers do indeed produce net social benefits, the externalities associated with transfers should be taken into account. Since the buyer and the sellers cannot be expected to do this voluntary, "government oversight of water transfers may be in the social interest" (Frederick and Kneese, 1988). Such policy-induced transaction costs could, at least in theory, enhance economic efficiency (Colby, 1990b).

Transaction costs may exhibit increasing, constant, or diminishing returns. Economies of scale have been identified in policy-induced transaction costs in a number of regional water markets in the western United States (Nunn, 1989; MacDonnell, 1990; Colby, McGinnis and Rait, 1989). The economies of scale observed for relatively small transactions may not be generalizable to larger transfers, particularly long distance geographic transfers between uses. Very large transactions can generate attention and opposition that result in high transaction

costs (Colby, Crandall and Bush, 1993). In addition, negative external impacts often increase, sometimes non-proportionately, with the size and distance of water transfers.

Some components of transaction costs can be independent of the quantity transferred. The title search, filing fees, and other similar costs often do not vary significantly with the quantity of water being transferred. This penalizes smaller trades and favour larger trades. Fixed transaction costs often result, therefore, in a bunching of transactions (Niehans, 1987). Other transaction costs, such as, brokers' commissions, may be proportional to the amounts or values traded and the effect is to reduce the quantity of goods traded (Crouter, 1987). Diseconomies of scale are most unlikely, since parties can simply split their transactions into smaller trades in order to reduce transaction costs.

Transaction costs tend to increase rapidly as exchanges increase in complexity and the heterogeneity and specialization of the commodities being traded. Given that water rights are multi-dimensioned goods and their value depends on many legal and hydrologic characteristics, it is not surprising that most water marketing systems involve relatively simple bilateral transactions, rather than complex multilateral contracts.

Transaction costs can affect the spacial concentration of market activity. Water trading tends to be concentrated spatially in the areas where transaction costs are lowest. In Texas, for example, the major market activity is concentrated in the Lower Rio Grande Valley where transaction costs are low (Chang and Griffin, 1992). Transaction costs can also affect the choice of the type of transaction. For example, if the transaction costs associated with a permanent transfer exceed those of a lease, as they often do, then buyers and sellers will seek to avoid the high transaction costs of permanent transfers and will prefer leasing to sales (Crouter, 1987).

In the states of Colorado, New Mexico and Utah, transaction costs incurred by applicants to satisfy state regulation averaged 6% of the prices paid for water rights (Colby, McGinnis and Rait, 1989). A recent empirical study indicates that, in Chile, transaction costs are particularly low in the areas with modern infrastructure and well-developed water users associations (see Table 4).

1. Non-policy-induced transaction costs

The efficiency of competitive markets rests on the assumption that (i) either good, reliable and easily accessible information is available on prices and other attributes of water commodities, water availability, quality and costs of supply over time, the identity of buyers, sellers and market intermediaries, and the procedures required to negotiate and complete a transaction; or (ii) where there are efficient contingency markets to allocate risks associated with imperfect information. In practice, such information is not always available, in part because producing and dissimilating information has many features of public goods, and acquiring it is often costly and difficult. In addition, markets to redistribute risk usually are incompletely developed due to uncertainty about the nature of the risk and the asymmetry of information between market participants (Saliba and Bush, 1987). On the whole, however, information requirements for efficient water marketing are no greater than those needed for an effective administrative allocation of water (Easter, 1994).

Table 4

Transaction and transportation costs in water trading in Chile

	Elqui Valley		Limarí Valley	
	Buyers	**Sellers**	**Buyers**	**Sellers**
Total transaction and transportation costs as a percentage of transaction price	2	2	5	2
As a percentage of total transaction and transportation costs				
• Costs of attorney's, notaries, and obtaining legal inscription of rights	59	79	16	34
• Costs of engineering and modifying canal infrastructure[1]	20	3	64	62
• Opportunity cost of time invested	20	18	18	0
• Costs of gathering information on buyers and sellers	0	0	2	4

Source: Hearne and Easter (1995).

Note: The discrepancy in some totals is due to rounding.
[1] Estimated expenditures for engineering services, modification of gates and canals, and indemnities for transferring water through canals. Includes expenditures up to the time of the study and does not include planned expenditures for modifications needed in the future.

A study of water markets in the western United States concluded that all markets studied were characterized by varying degrees of uncertainty and incomplete access to market information on water commodities, prices and market opportunities (Saliba *et al.*, 1987). "Currently, access to information regarding the purchase of a water right is a cloak and dagger operation. It is certainly not like buying stock on the New York Stock Exchange" (Tucker, 1995). Lack of accurate information increases uncertainty, affects the quantity and pattern of water transfers, and hence the capacity of the market system to reallocate water efficiently and the degree to which prices accurately represent values.

Where there is no ready means for buyers and sellers to obtain information, potential markets participants face legal, hydrological, and economic uncertainties in the decision making. Transaction costs, coupled with uncertainties as to the result of attempts to transfer water rights, constitute a substantial disincentive to engage in water marketing. Transaction costs are incurred in an effort to acquire accurate information, i.e., to reduce uncertainty and create security. Their magnitude depends on the structure of the market and the frequency with which water rights holders participate in the market and the nature of the commodity traded.

The effects of transaction costs tend to be ameliorated in markets with relatively large number of potential buyers and sellers which frequently participate in market transactions. In active markets, the prevailing price is often a matter of common knowledge. As the pool of potential trading partners increases, it should be easier for potential trading partners to identify each other, thereby lowering transaction costs (Stavins, 1995). A larger number of market participants can also mean more frequent transactions, generating more and better

information, and thereby reducing uncertainty and transaction costs. Conversely, transaction costs tend to be larger when there are few potential traders, or traders are highly disparate in size. This observation suggests the inconvenience of public policies which artificially limit the number of market participants and indicates a clear need to broaden access to property rights in water to all interested parties, including investors, environmental interests, etc. The frequency of transactions is also important: the higher the number of transactions in which a buyer or seller participates, the better his or her knowledge of the requisite information (Brajer *et al.*, 1989). Unfortunately, the frequency of participation in water markets, as in residential property markets, is likely to be relatively low. The institutional framework for water marketing can be designed, however, to reduce transaction costs and to provide information needed by potential traders.

There are several things public authorities can do to reduce non-policy-induced transaction costs, including: (i) ***removing barriers to private intermediary or brokerage services***; (ii) ***establishing a clearinghouse or a computerized register*** to provide a centralized location for water rights transaction or providing water rights banking and brokerage services to facilitate trades between private parties (this might be especially useful in thin markets, in the early stages of market development when potential market participants have little experience with market transactions, and where water rights holders are poorly organized and there is little communication among them); and (iii) ***facilitating access to a certain amount of basic information*** regarding market activity, regulations governing water transfers, the quantity and variability of the water supply over time, etc.

Private provision of intermediary services can play an important role where there are search, information, bargaining and decision costs. Intermediaries can also play the role of consultants, and assume risk by buying, selling, and holding water rights. Although intermediaries are recipients of transaction costs, their activities are welfare improving because they reduce transaction costs below what they would otherwise have been. Private provision of intermediary services is likely to emerge in relatively large markets where economies of scale permit the profitable operation of intermediary services and other institutions to facilitate trading. In some areas, water markets can to be too thin to be profitable for intermediaries specialized exclusively in water rights trades to emerge. As a result, already existing groups, such as real estate brokers, attorneys, etc., are likely to assume these functions, as has occurred in Chile. In Chile, offers to purchase water rights are advertised in newspapers and water-user associations maintain information on prices in recent transactions (Rosegrant and Binswanger, 1994).

Public authorities can facilitate market transfers and reduce transaction costs by establishing institutions which act as a centralized clearinghouse for potential buyers and sellers of water rights. These institutions can create and maintain a list of buyers and sellers seeking to enter into water right transfers, leases, or exchanges; communicate bids and offers; provide information and technical assistance to buyers and sellers; assist them in the negotiation of contracts to buy, lease or sell water rights; and provide other intermediary services.

This approach is widely used in the western United States where centralized institutions of state or local governments are the predominant model for managing water transfers (Water Facts Group, 1996). They perform the oversight, management, and control functions needed to overcome the informational limitations of water markets and to deal with external effects helping reduce policy-induced transaction costs. It is often complemented by

water banking (e.g., in California, Idaho and Texas) and other similar programmes, some of which involve sophisticated communications technology. The Westlands Water District, for example, has recently established an electronic water exchange, which operates as an electronic bulletin board where interested parties can post and read offers to buy or sell water, access information on average prices and trading volumes, and even negotiate transactions (Fikes, 1996; McLaughlin, 1996; Zachary, 1996). "Water banking implies some form of organized water trading with a clearinghouse to facilitate transactions" (Frederick, 1993). Under the water banking approach, water rights are traded through a government agency and prices, timing, eligibility of water rights, priorities, and eligibility of recipients are often regulated. Transactions are usually in the form of short-term leases. Transactions costs are reduced by standardizing the terms of transfers and streamlining contracting and negotiations. Such banks can be structured in several ways from a minimum of serving as an information clearinghouse for potential buyers and sellers to actually creating a market with the bank buying and selling water (Western Governors' Association, 1996). Operating costs can be funded by a charge levied on transactions. The implementation of water banking is often accompanied by measures to reduce policy-induced transaction costs (e.g., waiving some regulatory restrictions on transfers).

Transaction costs can also be reduced by raising the level at which trades are negotiated from the level of individual water right holders to a higher level, such as water users associations. Water user associations can provide the management component necessary to implement water transfers and serve as sources of information for those water rights holders wanting to engage in trading (Easter, 1994). Their records can provide information on water rights ownership, recent transactions, and water supply, etc., while their offices can serve as informal clearinghouses helping prospective trading parties locate one another.

2. Policy-induced transaction costs

Transfers of water rights can have both positive and negative effects on those who are not party to the decision process or transfer negotiation. The existence of externalities raises the possibility that a transfer may be beneficial to the buyer and seller, but inefficient from an overall social perspective. To the extent that water transfers are associated with significant externalities, market prices will deviate from the true opportunity cost of water, and hence will neither convey accurate market signals, nor encourage efficient water use and transfer decisions. Economic efficiency requires that all costs and benefits associated with use and transfer decisions be accounted for. In the United States, this requirement in embodied in the "no harm" or "no injury" rule "permitting those who are not parties to a transaction to object on the grounds that their rights may be harmed" (Getches, 1988).

While externalities can emerge under any allocation system, they pose a particular problem for water markets, when water use and transfer decisions are decentralized to the level of individual users. Since externalities arise at the boundary of decision units, the decentralization of water use and transfer decisions implies the maximization of decision units, and *ipso facto* the number of boundaries across which externalities might travel (Bromley, 1991). This fragmentation of decision points introduces greater complexity in the control of externalities and "tends to increase the information, bargaining, and contracting costs of agreement and therefore weaken the potential for negotiation to discover joint gains" (Shabman and Cox, 1995).

(a) Implications for water marketing

From the viewpoint of economic efficiency, water rights holders must face the full opportunity costs of their actions, so external effects should be accounted for in transfer decisions. If institutional arrangements do not cause buyers and sellers to account for external effects of their decisions, a transfer may be beneficial to the trading parties, but actually inefficient from an overall social perspective. Economic theory prescribes that the proper role for governments is to intervene in a manner that will correct any external effects and restore or substitute the requisite conditions for economic efficiency. There are several policy options open to governments regarding externalities whether arising from water marketing or not, but "even the most sophisticated market systems for water rights have yet to offer the complete resolution of all third party effects" (Simpson, 1994a).

Firstly, a government might decide to ignore externalities and do nothing leaving the problem to voluntary resolution. Even though this approach implies that society will sustain a welfare loss, there may be cases where this approach is worth taking, particularly where externalities are small both absolutely and in relation to the costs of regulation. This will be the case with many local transfers. Externalities are usually ignored in informal water markets which exist in a number of countries.

If externalities are small, they can be ignored with little ill effects for third parties. Ignoring large externalities "introduces a potential for misallocation due to lack of information and poor structuring of incentives" (Nunn and Ingram, 1988). Failure to internalize externalities can accentuate distributional or equity problems. The nature of the externality is also important. In the western United States, for example, the laws and institutions governing water transfers provide protection to third parties from many but not all negative externalities of such transfers (Howe, Lazo and Weber, 1990). Some parties who may experience significant externalities are specifically excluded from filing protests and from influencing the conditions of transfer approval (Colby, 1995). In general, only water rights holders can force their interests to be accounted for, while other impacts are addressed in only a few states (Colby, 1995 and 1990b).

Secondly, a government might decide to forbid water transfers in the presence of any externality due to "the difficulties of identifying and compensating adversely affected third parties" (Young, 1986). This approach is based on the implicit assumption that all externalities or their regulation are infinitely costly. Forbidding water transfers in the presence of externalities is grossly inefficient because water supplies remain locked into suboptimal use patters and many beneficial transfers do not take place, so efficiency losses can be substantial.

Thirdly, a government might decide to try internalize externalities by levying taxes on those creating negative externalities and paying subsidies to those creating positive externalities. This approach is increasingly used in many areas of water resources management, for example, water pollution control, but not for the externalities associated with water rights transfers. The use of taxes is sometimes advocated, however, for area-of-origin effects. The major difficulty is obtaining information (Laffont, 1987). To determine the optimal rate for such a tax or subsidy, regulators would require complete centralized information on all parties' marginal costs and benefits, which is dispersed among affected parties and cannot be efficiently acquired by regulatory agencies (Colby, 1990b and 1995).

Fourthly, since the ultimate cause of externalities "can conceptually be traced to a lack of definition of property rights" (Boadway and Wildasin, 1984), a government may decide to solve the problem of externalities in water transfers by clearly specifying property rights and enforcing them, and establishing an institutional structure for negotiations among rights holders. This approach is difficult to apply and is almost never used for most externalities involved in transferring water rights because property rights for other attributes of water, such as quality, are even more difficult to specify, enforce and make exclusive than for water quantity. In addition, transaction costs would be prohibitive since, because of inseparabilities in most uses, most transactions would involve two or more types of rights simultaneously. The use of this approach is sometimes advocated, however, for return flow effects.

Finally, a government might decide, as most countries with formal water markets have done, to address the problem through administrative or judicial means (see Figure 1). Water users organizations, regulatory authorities and the judicial system typically review water transfers in administrative, quasi-judicial or judicial hearings. Water user organizations or public authorities are typically the first arbiter; if the solution is not satisfactory to either party, the case may be brought to the courts or even require a political solution. These procedures can involve substantial policy-induced transaction costs and are a significant factor in determining whether a potential transfer can be implemented or not. The central question for regulatory policy is what institution should be used to collect and process information on and account for externalities associated with water transfers (see Table 5).

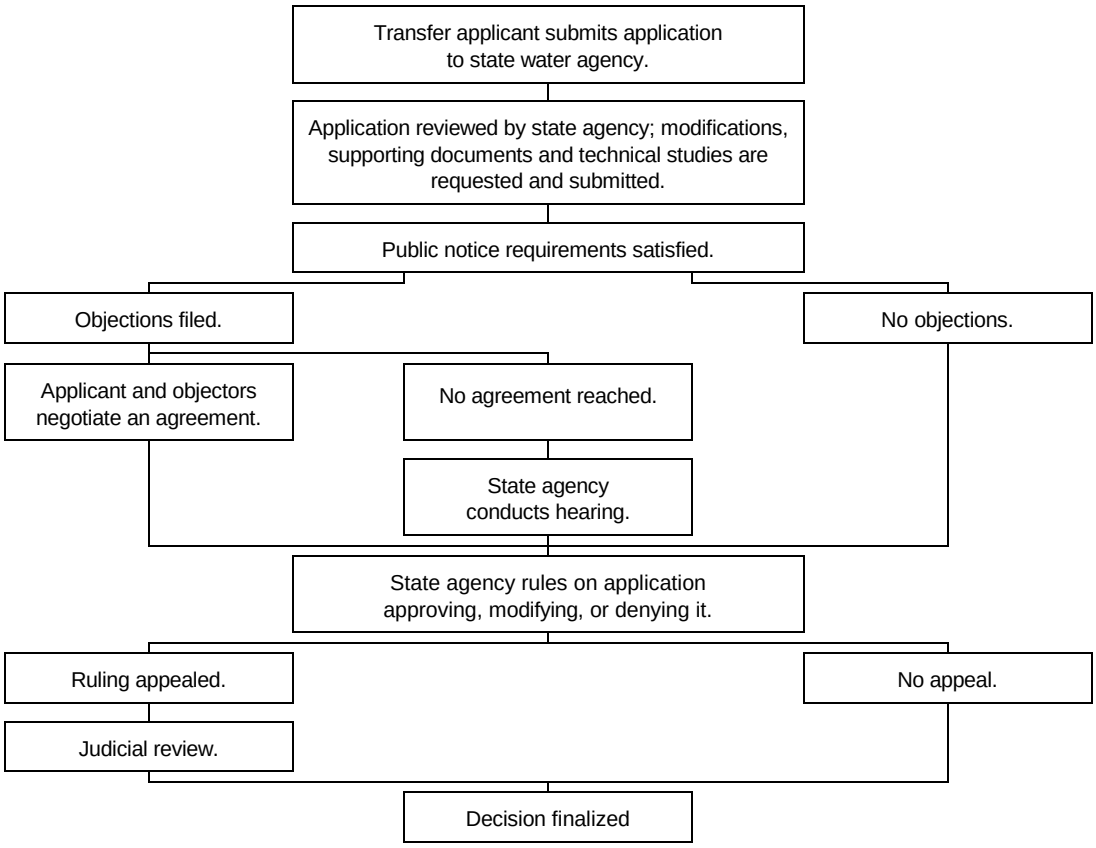
Regulations which force consideration of externalities that otherwise would not be accounted for in private negotiations between buyers and sellers, impose transaction costs on market participants in the form of transfer approval requirements (Colby, 1988). Therefore, appropriately structured policy-induced transaction costs are not a net waste of resources, but may facilitate efficient water transfers by giving traders an incentive to account for social costs of transfers (Colby, 1990b and 1995). High policy-induced transaction costs are not necessarily bad, rather they "reflect the substantial and multiple economic benefits associated with water in various uses, benefits which can be impaired by a transfer" (Colby, 1990b).

(b) Implications for regulatory policy

While economic efficiency requires that all externalities be accounted for in market decisions, regulations designed to protect third parties are a major component of transaction costs and these costs may be large enough to prevent water from moving to

Figure 1

The regulation of water rights transfers in the western United States



In the western United States, in general, water rights are transferred by a deed of conveyance with the same formalities as in real estate transfers. In order for a transfer to occur, the water rights must have been beneficially used and must continue to be beneficially used following the transfer. A water right holder must obtain a prior administrative approval, although in some cases, prior judicial approval or prior approval by the legislature is required. In most states the burden of proof that no harm will result is on the transfer proponent. Different types of externalities are accorded different degrees of protection with particular attention being paid to effects on return flows. Other external impacts are considered in only a few states. In general, the transfer must be in the public interest, and in many jurisdictions, the local public interests of the area of origin must be considered. The relevant considerations may include environmental, economic and social effects of the transfer. The party seeking to transfer a water right must file an application with the state water agency, specifying the desired modification. All states require public notice of the intent to transfer to inform parties whose rights may be adversely affected by the transfer so that they may contest the application. State water laws specify both who can legally file a protest with the state and the reasons for which a protest may be filed. When a transfer is protested on valid grounds, transfer approval is delayed as the applicant and protestants discuss the magnitude of adverse impacts and the nature and extent of mitigation or compensation. State water agencies encourage private conflict resolution. If the parties fail to reach a negotiated solution, the state water agency will hold hearings and rule on the transfer application. Parties dissatisfied with the decision may appeal to the legal system.

Source: Colby (1995) and (1990b), Getches (1990), and Anderson, Maddox and Simmons (1991).

Table 5

Regulating transfers: how different institutions collect and process information on external effects of water transfers

	Information	Result
Unregulated markets	Markets efficiently generate information on direct costs and benefits, but ignore indirect costs and benefits.	Transaction costs are low because indirect effects are ignored. The transfer may be beneficial to the trading parties, even though it is inefficient from the overall social perspective.
The irrigation district or user association	There are incentives to generate and present information on external effects, but the response to it depends on the political dynamics of the district. A property-weighted electoral system is likely to be biased against external effects, while a one-person/one-vote system is likely to be biased towards dispersed effects.	There are incentives to exploit the transaction's flexibility while adapting terms of transfer to local concerns. Such districts may often become the tool of a small group of members, pursuing narrow goals with low levels of membership participation. The decision making process is biased toward interests which identify with the purpose which motivates the formation and continued existence of the district.
The public administration	The biases of administrative agencies depend on their missions, the disciplinary background and expertise of personnel, and the kind of analysis required by the regulations under which they operate. If these regulations dictate a consideration of external effects, they will be formally considered, but the extent to which they will actually be incorporated in the decision making process depends on the political setting within which the agency operates.	Administrative agencies are heavily biased in favour of information that supports their missions. Historically, administrative agencies have not been especially sensitive to external effects. These biases can be modified to some degree through the rules for specific actions, particularly if reinforced by an oversight body representing protected interests.
The courts	Courts are concerned with the protection of legally established interests rather than with maximizing net social benefits. In their decision making, courts do not generally weigh the magnitudes of direct and indirect effects. A rule of law defining certain legally protected interests often develops before some class of affected parties has identified itself. Such rules are difficult to modify without injury to established interests and courts are usually reluctant to change them.	In the evolution of judicial doctrine, courts consider the public welfare effects of the rule that is being adopted. Judicial doctrine evolves towards recognition of previously unprotected concerns, subject to the constraint that previously protected interests should not be unreasonably damaged. The courts are unlikely to be especially sensitive to externalities because the standing to sue and justiciable rights of third parties are not well established.
Legislatures	There are incentives for interest parties to generate information about externalities and to seek arrangements and compromises to minimize them. Legislatures may be reluctant to protect the newly discovered interests because of their sensitivity to concentration of established interests.	There is no general bias against indirect costs and benefits. There is a bias in favour of impacts that are immediate and concentrated on special interest groups, but widely dispersed costs and benefits are not well considered. Legislatures often systematically distort information on direct costs and benefits.

Source: adapted from Nunn and Ingram (1988).

higher-value uses. The procedures for market transfers can sometimes be so restrictive, and hence policy-induced transaction costs can be so high, that the benefits the marketing approach offers are more imaginary than real. "The main issue in making markets work more efficiently is to identify and quantify these effects accurately and quickly and to get agreement on their magnitudes so that compensation and/or adjustments to the original property rights can be carried out without excessive transaction costs" (Howe, Schurmeier and Shaw, 1986b). The challenge is to develop institutions that provide protection from negative externalities without imposing high policy-induced transaction costs. Public policies should seek to balance the transaction costs necessary to insure the consideration of externalities that would otherwise be ignored by transfer proponents in unregulated markets with the goal of facilitating transfers for which social benefits exceed social costs. There are several things public authorities can do to ensure that policy-induced transaction costs are neither excessive nor insufficient to achieve their intended effect.

Public policies should seek to avoid excessive regulation. Since regulation of water transfers imposes direct and indirect costs on water users as well as on the rest of the economy, these costs must be carefully weighed against the objectives that regulation seeks to accomplish. It is equally important to avoid adopting laws and policies that create uncertainty regarding the conditions under which a transfer may or may not proceed or regarding how much water can be transferred and for what purposes (Colby, 1988 and 1990a). The uncertainty over the rules governing a market may prompt market participants to overinvest in transaction costs and is likely to discourage expanded market trading by reducing incentives for market transfers. Policy-induced transaction costs can often be substantially reduced by establishing a clearly defined set of transfer rules and incorporating into them adequate measures for third party protection, so that market transactions can take place at the behest of trading parties contingent upon compliance with this set of trading rules.

The attributes of water considered deserving protection should be clearly defined and incorporated into water marketing policies, and procedures developed to identify, value and protect these attributes. The laws and institutions governing water transfers should be designed to generate adequate information on the externalities associated with water transfers and facilitate monitoring and enforcement in a least-cost manner; and to ensure that all parties have the means to comply with their requirements, given the will to do so. Reliable hydrological information is essential to determine who would be affected by a transfer and the magnitude of injury.

Public policies should seek to provide both an efficient forum for negotiation and access to coherent and reliable information. Administrative procedures which initially bring all the parties concerned together informally to negotiate compromises and compensation reduce policy-induced transaction costs, while those procedures which require a formal hearing and presentation of evidence increase them (Colby, 1988). The judicial system should not be the first forum for evaluating a transfer proposal, but should generally be the last and final forum for conflict resolution. Access to reliable information is also important as "in the presence of information deficiencies, players will tend to bargain from worst-case assumptions about adverse impacts on their welfare. If this is the case, negotiated solutions are limited because the compensation demanded from other parties may be increased unrealistically" (Shabman and Cox, 1995).

Water marketing leaves more decisions to private bargaining and hence puts a greater burden on the judicial system to coordinate the various interactions among different resource

uses and users, and ultimately, to resolve conflicts when private bargaining fails to reach a negotiated solution (Bauer, 1995a and 1996). Water markets need an active and non-formalistic judicial system which is capable of resolving private conflicts through simple, fast and low-cost procedures with predictable and consistent results.

An efficient administrative process is needed to monitor, enforce and record transfers. The existence of many unregistered and not clearly defined water rights introduces uncertainty into the water allocation system, increases transaction costs, impedes efficient monitoring and enforcement, and makes information difficult and costly to obtain.

B. Transportation costs and infrastructure requirements

The efficiency of competitive markets depends on water being relatively mobile. Adequate infrastructure allows for broader access to water markets by water buyers and sellers, and hence promotes competition and helps ameliorate the problem of market power. In India, for example, substantial private investments in pipeline networks have made water markets more competitive (Dinar, Rosegrant and Meinzen-Dick, 1997). Adequate infrastructure also permits dealing more efficiently with externalities, as the experience of the Northern Colorado Water Conservancy District suggests (Howe and Goodman, 1995). Markets will operate less efficiently and there would be fewer potential traders in instances where it is difficult or expensive to move water from one user to another.

On the other hand, many transfers can be accomplished without elaborate infrastructure. Empirical evidence from Chile where markets operating with relatively unsophisticated technology produce substantial economic gains-from-trade, and experience of geographically limited water markets in other countries, suggest that water marketing can be beneficial even when the trading areas and the number of potential buyers and sellers are relatively small. In addition, secure water rights and their transferability provide strong incentives to water rights holders to invest in the development and maintenance of hydraulic infrastructure. Since traders must bear all transportation costs, they are likely to be more attentive to cost effectiveness in infrastructure design and scale, so as to minimize transportation costs.

Transportation costs represent a financial burden to trading parties, both in terms of the direct costs associated with a transfer and the opportunity costs of time delays while waiting for infrastructure modification or construction, and hence reduce the profitability of water transfers and the amount buyers are willing to pay for water rights, and affect the level of market activity and the number of potential buyers and sellers. When transportation costs exceed the potential gains from trade, the incentive to participate in the market is lost. This means that transportation costs can suppress transactions that otherwise would have been mutually and socially beneficial.

Transportation costs prevent market transfers from equating marginal water values among locations resulting in persistent price differentials. If there are differentials in the productivity of water in various uses and locations, it must be possible to move water to the use and location in which its productivity is highest. If water right transfers do not involve high transportation costs, there would be small price differentials associated with the original location of a water right. Where the necessary infrastructure is lacking and transportation costs are high, market prices will differ for water rights with similar characteristics that are located in different locations. Thus, high conveyance costs increase price dispersion.

Unless gains from trade are so large as to make investments in a new transportation system worthwhile, a water right has little value to users outside the area within which it can be moved at a reasonable cost. The costs of transporting water long distances out of its natural channels is usually high relative to its value in most uses. Typically, only very large transfers justify the cost of constructing new transportation systems. It is for this reason that in most countries, there are no national or regional water grids, and virtually all water systems are independent and not interconnected, except by shared natural water bodies which provide natural conduits for water transfers along which regional water markets develop. Consequently, water markets usually exist in the form of relatively independent regional markets defined by river basins, rather than entire regions or nations (Livingston, 1993).

The gains-from-trade and the ability of any given market to ensure efficient use and transfer of water depend on the size of the area within which the water may be transferred at a reasonable cost and the number of sellers and buyers in that area. All else being equal, larger trading areas and larger numbers of traders offer better opportunities for larger gains-from-trade and for improved market operations due to the wider set of trading opportunities made available. Regional water markets in the western United States show a significant relationship between market prices and the size of geographic areas within which the water rights may be transferred (Colby, Crandall and Bush, 1993; Saliba *et al.*, 1987; Gardner and Fullerton, 1968). The limits placed by physical geography and infrastructure have been cited in a number of studies as one of the factors explaining the relative inactivity of the Chilean water market (see Box 5) (Peña, 1997; Bauer, 1995b).

The availability of conveyance infrastructure is usually not a significant constraint for trades between water users drawing water from the same water body and for trades among neighbouring users within the same water distribution system. For transactions involving interbasin transfers, transfers from downstream to upstream areas in steep basins, other transfers requiring energy for lifting/pumping, and transfers within large water distribution system with few control structures or limited canal capacities infrastructure becomes all important.

Since it is usually not economically efficient to build canals and other hydraulic structures and to use them only intermittently, the availability of conveyance infrastructure is particularly important for short-term water transfers. Even where the necessary conveyance infrastructure is in place, the high fixed costs of infrastructure modification to accommodate water transfers can put short-term and small-scale transfers at a comparative disadvantage in relation to permanent and large-scale transfers. In Chile, for example, intra-agricultural leasing takes place only between farmers diverting water from the same or very near canals because of the high costs of long-distance trades (Gazmuri and Rosegrant, 1994).

Box 5

Limits placed by physical geography and infrastructure on water market activity in Chile

In Chile, the narrow central valley, where most of the country's irrigated land is located, is divided from north to south into a series of fairly small, short and steep river basins separated by hills, which make it expensive to transfer water between neighbouring basins, or from downstream to upstream areas within the same river basin. Inadequate infrastructure for storage, diversion and conveyance also acts as a constraint on water transfers. As a result, transportation costs are often high except for transfers between neighbouring or nearby users on a shared canal system.

Partly because the Andean snowpack provides natural, short-term water storage, substituting for artificial reservoirs, but also because of the high costs involved, Chile has few medium to large reservoirs for irrigation, and thus very little long-term storage capacity. Most storage has been constructed for the generation of hydroelectricity. Because of inadequate storage capacity, most of the hydraulic infrastructure has been designed, built and operated for diverting water from unregulated rivers with highly variable flows.

The water flow in most canal systems is controlled by weirs, "*bocatomas*", diverting water directly from the river's edge to the head of the canal. In many systems these are temporary structures which have to be rebuilt or repaired every year. This allows some flexibility in water transfers but makes it difficult to quantify the diverted flow. In the canal systems which employ more permanent concrete structures, problems arise because the works have been built to divert specific proportions of the natural flow and are often hard to convert to different specifications.

Within canal systems distribution works are also inflexible. Since many systems use "*marcos partidores*" or flow dividers, designed to distribute fixed proportions of changing flows, most water transfers from one farmer to another require the re-calibration and modification of all intervening flow dividers to ensure that the water rights of other users are unaffected. Except for minor transfers, any changes are often prohibitively expensive. Any modification is even more complicated for trades outside the tertiary canal.

Some systems employ "*compuertas*" or adjustable gates to divide the water flow allocated to different users. "*Compuertas*" allow more flexibility for water transfers and help reduce transportation costs, because water flows can be modified without modifying the infrastructure itself by simply lowering or raising the corresponding gates. Operating and monitoring costs are, however, higher than with less flexible infrastructure, principally because more flexible infrastructure requires more monitoring and control of the users' behaviour.

The poor levels of construction or maintenance of canal infrastructure impose limits on the precision with which transfers can be made. In addition, canal systems servicing many farms resulting from the Agrarian Reform were originally built for large farms and are usually poorly suited to deliver water to many smaller ones. Finally, some water user organizations lack adequate managerial capacity to operate and maintain the irrigation works under their responsibility.

The observed levels of market activity are closely related to infrastructure availability with water markets being more dynamic and effective in areas with better infrastructure and well-organized water users associations. In contrast, market transactions are less common in areas where there is no storage and where large canal systems use fixed flow dividers.

Source: Bauer (1995b) and (1997), Hearne and Easter (1995), and Ríos and Quiroz (1995).

In areas characterized by high variability of precipitation and streamflow, the development of storage facilities to capture water during periods of abundant water supplies and preserve it until times of lower supplies and higher demand is the principal technical response to the need to make water rights relatively secure. The availability of supplementary groundwater supplies can perform a similar function.

The lack of adequate measuring devices can discourage market transfers both because potential buyers may be reluctant to engage in trading unless they know they will receive all the water they pay for and because third parties, not being able to ascertain the exact volume of transfers, may be concerned that their rights will be affected by unmonitored transactions. Community participation through water user associations can often substitute for technological solutions and reduce the costs of monitoring and enforcement (Easter and Feder, 1996). Water user associations can monitor water use and enforce the distribution of water at low cost and use peer pressure as an effective and low-cost enforcement mechanism.

The operation and maintenance of infrastructure is important as poor operation and maintenance increases water losses, and hence transportation costs, and imposes limits on the precision with which trades can be accomplished. The need to ensure adequate operation and maintenance underlines the crucial role of water user organizations in water marketing and the need to encourage private sector participation in water-related infrastructure expansion, operation and maintenance.

Transportation costs include also the costs of infrastructure modification to accommodate transfers. These costs are likely to be high because of the rigidity of most of hydraulic infrastructure. The operation of existing conveyance and storage facilities is likely to require significant changes to facilitate water transactions, as most systems have not been designed with the needs of water marketing in mind (Israel and Lund, 1995).

The coordination of water transfers is important because transfers often involve interlocking delivery network systems characterized by substantial interactions in the provision of flows to individual users and in the accommodation of changes. In most networked infrastructures, supply and demand are not separated, but closely interrelated (Barraqué, 1993). It is essential to maintain equilibrium between supply and demand continuously and throughout the network. The efficient and reliable supply will not be achieved without a coordination mechanism regarding technical operation, connection procedures, transmission protocols, etc. Such coordination can be handled either through a decentralized system of contractual relationships or a centralizing coordination mechanism.

The former approach may prove difficult to implement in practice where there are many small water users and where the costs of organization are high, as may be the case in the areas with no tradition of collective action. For example, a study of irrigation in Pakistan found that the coordination of turns in the water market is a difficult task when a system is abused by the powerful farmers (Mirza, Freeman and Eckert, 1974; Renfro and Sparling, 1986). In contrast, in Chile, user participation has a long and successful history. Water users organizations regulate and administer the water resources and related infrastructure under their respective jurisdictions and own most irrigation and drainage works, including dams and reservoirs. A centralized approach is probably necessary when there is very elaborate network infrastructure capable of transferring water over large distances, as demonstrated by the experience of the drought water banks in California. Whichever approach is adopted, "water systems need to have a certain level of management capabilities to execute the desired trades" (Easter and Feder, 1996).

Where market forces do not produce an optimal level of storage, conveyance and distribution infrastructure, some form of government regulation or direct participation in the financing, operation or management of these infrastructure elements may be justified. A study by Shah and Zilberman (1995) suggests that, "high costs of monitoring and conveyance are

likely to be an additional important factor in preventing the move to water markets", and that "in some cases, government subsidization of monitoring and conveyance as well as availability of information (extension) costs could be justified on grounds of improving social welfare". A study of gains-from-trade in the water markets operating in Chile, showed that public investments in water storage and delivery systems have the external benefit of reducing the transportation and transaction costs involved in market transactions (Hearne and Easter, 1995).

Government participation may also be useful where the areas over which extensive conveyance facilities are to be constructed are private properties. The acquisition of the necessary areas is likely to be considerably cheaper and easier when undertaken by a government because: (i) the piecemeal negotiation by private parties entails high transaction costs and potential delays; and (ii) governments enjoy "eminent domain" privileges to override private property rights (Easter and Feder, 1996). On the other hand, most conflicts over rights-of-way can be resolved by voluntary private bargaining, provided that there are clear rules about how these rights can be exercised and conflicts resoled.

Where water transfers involve the use of publicly owned water facilities, it is important to ensure that their administration collaborates with private water rights holders and facilitates water transfers initiated by private parties by proving access on a fair basis to its unused facilities or capacities to transport or store water. There regulations should incorporate appropriate safeguards for agencies that control facilities. Another option is to encourage private sector participation in the management and operation of hydraulic infrastructure.

In California, for example, the "Model Water Transfer Act for California" provides that a water user who transfers water or who receives transferred water may use up to 70% of the unused capacity of water supply systems, including diversion, storage, transportation, treatment, distribution, and related facilities, owned and operated by public agencies to transport the water (Gray, 1996). Under this proposal, the agency may impose reasonable terms and conditions on the use of its water supply system to comply with applicable water quality and environmental standards, and has authority to charge the water user for the costs attributable to his or her use of the system less the value of any benefits to its water supply system that result from the transfer.

The Metropolitan Water District of Southern California has adopted two guiding principles to analyze potential wheeling agreements and to fix wheeling charges (Metropolitan Water District, 1996, 1997a and 1997b). The principle of "equal treatment" of water purchased by its member agencies, whether purchased from it or wheeled from elsewhere, ensures that the distribution and storage system's unused capacity is available to all members on an equal basis. The "no harm" principle ensures that member agencies not participating in a wheeling agreement are protected from wheeling agreements that would negatively impact them with regard to water cost, quality or reliability.

IV. The regulation of external effects of water transfers

Externalities are pervasive in water resources management and in water transfers. It is useful to distinguish two broad groups of externalities which can be associated with water transfers: (i) ***physical or "return flow" effects***, such as changes in downstream flows with surface water transfers, and changes in the water table with groundwater transfers; and (ii) ***instream flow effects***, such as changes in fish and wildlife habitat, or recreation opportunities stemming from changes in streamflow, in water quality, or in the seasonality of streamflow. There are also the so-called "***area-of-origin effects***", such as effects on local communities, but these are usually ignored in economic efficiency analysis because they represent income redistribution rather than real welfare changes.

A. Return flow effects

Return flows occur because normally only part of the water withdrawn from a stream is consumed. The water that is not consumed will return at some point to the stream, either directly, by surface return flow, or indirectly, through groundwater, and consequently become subject to downstream appropriation. Whenever return flows are used by water users downstream, any change in the point of diversion or point of return, in the place of use or place of storage, in the purpose of use, or in the time of use which alters the established pattern of return flows can damage some users and benefit others (see Figure 2). In addition, since surface and groundwater commonly belong to a hydrogeologically integrated system, surface water rights transfers can affect the rights of groundwater users, and vice versa. Return flow effects can be significant, but there is often a time lag before they become noticeable, and it is often difficult to determine whether they are the result of the stochastic nature of river flows or an upstream transfer, and to identify the transfer in question.

It can be argued that return flow effects should be "properly viewed as a government, or legal, or analytical failure" because, it is possible, in principle, to define and allocate water rights in such a way that the rights of downstream users do not rely on return flows (Paterson, 1989). This failure can be attributed to the crude understanding of stream hydrology at the time of initial allocation and the possible physical and economic infeasibility of measuring return flows (Huffaker, Whittlesey and Wandschneider, 1993), but also to the need to promote more complete utilization of water resources. The problem can be avoided either by defining water rights as consumptive entitlements and not granting rights to return flows, as provided for in the Chilean 1981 Water Code, or by defining entitlements at the source and partitioning run-off, storage capacity, and evaporation and seepage losses. While this may be feasible in some circumstances, such as development of new water supplies under conditions of complete information about the water resources on which the rights are based, it can lead to difficulties where there are already formal and informal water rights based on return flows.

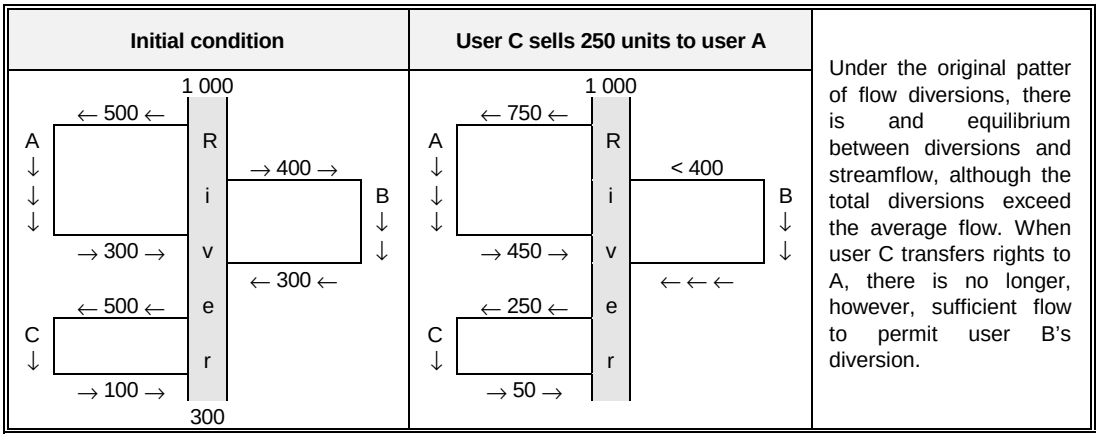
The importance of return flow externalities is likely to decrease over time as water use becomes concentrated in urban areas where wastewater disposal is effected through a central sewerage system (Howe, Schurmeier and Shaw, 1986a).

1. Implications for water marketing

Where water is scarce enough to be the object of market transactions, "there are also likely to be parties making use of the would-be seller's return flows" (Miller, 1987). The introduction of water marketing may require greater attention to the problem because of the need to clarify rights, more intensive water reallocation, and because the transferability of water rights provides strong incentives for water users to use water more efficiently and to invest in water conservation, thereby reducing return flows (Ríos and Quiroz, 1995).

Figure 2

Water transfers and return flow effects



Source: Griffin and Boadu (1992).

Return flow effects are a possible source of inefficiency in any transferable water rights system, because a failure to take these external effects into account may generate inefficient transfers in which social costs exceed social benefits (Howe, Schurmeier and Shaw, 1986a). In informal water markets, for example, there is no compensation for the return flow effects and this has resulted in sales by upstream users which decrease water availability to downstream users (Thobani, 1997). This potential for inefficiency implies that public policies that seek to protect third parties from return flow effects are desirable and can be justified on efficiency grounds because they: (i) ensure that only those transfers which result in a net economic gain to society as a whole are permitted, (ii) protect the interests of those under-represented in the market process, and (iii) provide security to water rights based on return flows, and hence promote more complete utilization of water resources.

On the other hand, these policies often are a major component of transaction costs and may impede socially desirable transfers and introduce inflexibility in water reallocation by unduly increasing the policy-induced transaction costs associated with them. In the western United States, for example, protection against return flow effects is a primary source of policy-induced transaction costs in most states (Saliba and Bush, 1987; Williams, 1983). In addition, the need to protect third party water rights holders relying on return flows and "the economic infeasibility of establishing elaborate conveyance systems between streams" can limit the geographical scope of water rights transfers resulting in thin water markets (Saleth, Braden and Eheart, 1991). Trade-offs exist between the benefits of protecting third party water

rights holders from return flow effects, the costs of formulating and implementing these policies, and the need to promote water rights transferability. These pervasive trade-offs underline the need to carefully weigh the costs of the policies to protect the rights of third party water rights holders against the benefits they are expected to generate.

2. Regulation of return flow effects

The policy options open to governments to regulate return flow effects include: (i) limiting trades to the consumptively utilized portion of a water right; (ii) establishing cooperative or other pooling arrangements within a given area; and (iii) establishing property rights over return flows (see Table 6). Whatever option is adopted, the regulation of return flow effects can be very complex and requires reliable and timely hydrologic and hydrogeologic data. The availability of such data requires considerable investment in facilities to create comprehensive monitoring and information systems.

In the ***western United States***, return flows are often protected by restricting the quantity of water that may be transferred to correspond to historic consumptive use rather than the historic quantity diverted and requiring that the transfer should not harm other water users (Saliba and Bush, 1987; Wahl, 1989; Griffin and Boadu, 1992). Determination of historical use may be based by actual records, if they exist, but they are rarely adequate; expert testimony, which is costly; or evidence (e.g., soil conditions, crop water requirements) of the amount of water that would have been required for the purpose to which it was devoted, which is difficult to obtain (Getches, 1990). This method can impose high transaction costs on market participants and some jurisdictions use standard conversion rates to streamline the transfer approval process. For example, in ***New Mexico***, the state administrative agency sets a standard quantity of water that may be transferred per unit of irrigated land, and parties who disagree with this quantity bear the costs of demonstrating that some other amount is appropriate, resulting in low policy-induced transaction costs (Colby, 1995, 1990b and 1988).

Some jurisdictions in the United States have adopted an alternative approach under which water rights holders in a given geographic area or river basin surrender their individual water rights to a centralized water purveyor, such as an irrigation district or a ***mutual water company***, in exchange for shares entitling them to a specified quantity of water (Gould, 1989). Water rights can then be transferred freely within the entire service area by the transfer of shares and return flow effects are ignored. A variation of this approach is used in the Northern Colorado Water Conservancy District for the allocation of water from the Colorado-Big Thompson project (Howe, Schurmeier and Shaw, 1986a). The Federal Government retains ownership of all return flows from the Project and these return flows are reserved for recapture and use by the District. As a result, water rights can be transferred without considering return flow effects. Downstream users benefit from return flows of upstream water users but they have no legal rights to them and if upstream users sell their water rights, return flows can be lost. The arrangement does not mean that there are no real impacts on downstream parties who rely on return flows, rather it relieves trading parties from liability for them. This arrangement coupled with the homogeneous nature of water rights, a high degree of hydraulic control achieved by the canal and reservoir system and an efficient administrative system drastically reduce transaction costs and facilitate market transactions. As a result, a very active and extremely sophisticated water market has evolved in the District.

Table 6

Regulation of return flow effects

	Limiting trades to the consumptively utilized portion of a water right	Mutualization and cooperative pooling	Establishing property rights over return flows
Mechanism	Water available for transfer is restricted to historic consumptive use and any water irretrievably lost to further beneficial use.	Users surrender their individual rights in exchange for shares entitling them to a specified quantity of water. These can be transferred freely only in a given area and return flow effects are ignored.	Water rights holders have full property interest in the return flows from their initial use.
Advantages	Internalizes most return flow externalities. Protects the rights of all users to continue using water in the same manner as before. Promotes complete utilization of water resources.	Drastically reduces transaction costs and facilitates market transfers.	Internalizes both negative and positive return flow effects and creates incentives for water rights holders to modify their water use practices so as to maximize the benefits of both consumptive use and return flows. Transaction costs associated with third party protection are likely to be reduced.
Disadvantages	High transaction costs. The quantification of the transferable portion of a water right is a complicated and time-consuming process fraught with considerable difficulties. Does not encourage transfers with positive return flow effects. Market activity is limited to trading consumptive entitlements.	Return flow effects remain a problem and a possible source of inefficiency in water transfers. Reducing the size of the market, reduces the opportunities for and potential benefits of market transactions.	Measuring the water returned is difficult and costly. Transactions are likely to become more complex and related components of transaction costs are likely to increase. This approach can lead to difficulties where there are already many formal and informal water rights based on return flows.
Comments	Possibly attractive where return flows are significant and where the rights of many users depend on return flows. Costs of determining rates of consumption can be reduced by adopting standard rates, but these can lead to errors.	Possibly attractive where the value of water is low, return flows are small, rivers are short, transfers are mostly local, and in areas served by large distribution systems capable of ensuring a high degree of hydraulic control.	Can be expected to expand as return flows become more valuable and as measuring costs are reduced.

Source: on the basis of California Department of Water Resources (1993), Gould (1989), Griffin and Boadu (1992), Howe, Schurmeier and Shaw (1986b), Saliba and Bush (1987), Scott and Coustalin (1995), and Williams (1985).

In ***Chile***, the 1981 Water Code defines water rights as full diversion and consumption rights, with no obligation to return water, and downstream users cannot have rights to return flows generated upstream. In practice, due to inconsistencies in the historical measurement of streamflows, rights almost certainly have been granted over return flows ("return flows are common in Chilean rivers, and are a very important source of water for many water users" (Ríos and Quiroz, 1995)). This creates a certain degree of insecurity over the property right and empirical adjustments are often made by the water user associations if transfers result in a reduction in return flows (Holden and Thobani, 1995; World Bank, 1994). The approach provides only a partial solution to the problem of return flows because it does not ensure that there are no real return flow impacts on downstream water rights holders, so there remains the possibility of inefficient transfers. Additional measures to protect users relying on return flows are used in those rivers with high return flows. These rivers are divided into sections and transfers between sections are prohibited (Ríos and Quiroz, 1995). In reality, several factors help reduce return flow effects. The most important of them is the use of proportional rights in many rivers. This results in any reductions in water availability, whether caused by water right transfers or not, being distributed among all users. The particular geographic characteristics of Chile also help reduce the return flow problem. Rivers are relatively short, with relatively rapid flows and consumptive water use is spatially concentrated in the middle and lower parts of the river basins with most intersectoral transfers occurring from upstream, mainly farmers, to downstream, mainly water utilities, users. On the whole, "the reduced return flows from water sales have not yet had a significant impact on downstream water users" (Easter and Feder, 1996), although it might be too early to pass definitive judgement on this point because of the limited number of transactions and because many transfers are from holders who do not use their water rights (Peña, 1996).

Finally, return flows can be protected by giving each water rights holder a full ***property interest in the return flows*** from his or her initial use, so that other water users may not use return flows without owner's consent (Williams, 1985). In quantifying water rights, two separate property rights in water would be established: a right to divert a fixed amount of water and a right to consume a fixed quantity of water (Griffin and Boadu, 1992). These rights can be traded independently or together, although because of inseparabilities in most uses, market transactions would likely involve both types of rights simultaneously (Griffin and Hsu, 1993). Extending water marketing to both types of water rights would offer significant benefits of internalizing both positive and negative return flow externalities and creating appropriate incentives for water rights holders to modify their practices of water use so as to maximize the benefits of both consumptive use and return flows. The likely effects include better incentives for water conservation and wastewater treatment, and hence less water consumption and, probably, more return flows (Scott and Coustalin, 1995). This approach is likely to reduce transaction costs associated with third party protection, although transactions are likely to become more complex and related components of transaction costs might increase. Transaction costs and the difficulties in measuring return flows aside, "economic efficiency in water use would call for the upstream appropriator to pay for the amount he withdraws and to be paid for the amount he returns" (Scott and Coustalin, 1995).

B. Instream effects

Water does not have to be withdrawn from a water body to generate economic benefits. Instream flows play an important role in such uses as, waste dilution and assimilation, providing a habitat for fish and riparian wildlife, and recreation. The benefits of such uses can be high in comparison with withdrawals (Colby, 1990a and 1990b; Daubert and Young, 1981; Ward, 1987). Failure to account for these benefits in market transactions can result in inefficient water transfer decisions.

1. The protection of instream interests in water markets

Public policies to deal with environmental externalities of water transfers can be either administrative or regulatory, seeking to protect instream uses through regulation of water transfers, or market-based, protecting instream uses through appropriation and acquisition of water rights for flow maintenance.

Regulation usually involves: (i) the establishment, monitoring and enforcement of ambient water quality and return flow quality standards; (ii) the reservation of minimum or ecological instream flows and levels, to be maintained regardless of water demand in other uses, and the withdrawal of specific water bodies from appropriation; (iii) land use controls, such as development restrictions for sites of ecological importance, the creation of national parks and other protected areas; and (iv) a transfer review process in which a regulatory agency can reject or modify applications for appropriation or transfer of water rights if they substantially affect protected instream uses. It is essential to ensure that the regulation of water quality is integrated with water rights administration and management.

The regulatory approach has an important weaknesses in that it is intrinsically inflexible, i.e., it stands “in the way of any compromise or trade between persons for whom levels for public uses have been provided and other persons, especially those holding water flow rights for individual uses” (Scott and Coustalin, 1995). One of the potential benefits of water marketing is that it provides a means for public and private interests to acquire water rights for instream flows maintenance, and hence presents new opportunities for instream flow protection and provides instream users with an attractive alternative to relying on the costly, protracted, and often unpredictable political process and litigation. It should be noted, however, that "realistically, one would not expect such behaviour to be especially prevalent" (Randall, 1981).

Since instream users do not divert water, they can enhance instream flows by purchasing upstream diversion rights and selling them to parties downstream from the location of their use, thereby achieving additional flow at intermediate points (Anderson and Leal, 1988). Such sales would have to specify that the buyer cannot transfer water to parties upstream. Obviously, this restriction would result in lower prices, "but that would be the price of preserving instream flows" (Anderson and Leal, 1988). Once the rights are sold, however, instream uses remain vulnerable to upstream transfers by other downstream water rights holders, because instream users will not have any basis on which to protest later transfers that reduce the instream flow that has been thus arranged (Livingston and Miller, 1986). The problem can be solved by purchasing upstream diversion rights and leasing them to parties downstream, because in this case, the water right remains with the instream user and can be protected against damage from any transfer (Livingston and Miller, 1986). Option contracts are an attractive alternative to purchases and leases, because they can protect instream flows during

dry years but do not tie up supplies during years when streamflows are adequate (Colby, 1990a). Another interesting alternative is to establish and manage a system of economic incentives to subsidize the reallocation of water rights to water users downstream and to tax upstream transfers of water rights as a means of enhancing instream flows and accounting for instream flow benefits (Griffin and Boadu, 1992).

In many western states of the United States, state agencies may acquire - through the appropriation or reservation of unappropriated water, dedication by private entities, or outright purchase - water rights to maintain instream flows (Saliba, 1987; Colby, 1990a and 1995). Although this authority has seldom been exercised, water transfers for streamflow maintenance are becoming more common. In acquiring these rights state agencies typically consider requests from other parties, but private parties generally may not hold rights for instream purposes (Livingston and Miller, 1986; Colby, 1995). Only a few states allow a private party to hold a right for the purpose of maintaining instream flows (Saliba, 1987; Colby, 1988; Colby, McGinnis and Rait, 1991).

Water markets in the western United States are undergoing important transformation. While initial market activity centred on transfers from agriculture to urban drinking water supply and industrial users, more recently, transfers have been initiated to enhance instream flow values and to resolve conflicts over the appropriate allocation of water between environmental instream and diversionary uses (Colby, McGinnis and Rait, 1991). Government purchases of water rights for instream flow maintenance have been used to increase the flow of fully appropriated streams where instream flows can be restored only by terminating the rights of existing users. In such cases, "purchasing rather than condemning existing water rights may be quicker and perhaps even less expensive when a voluntary transfer can avoid a lengthy legal struggle" (Frederick, 1993).

Not only has the public sector become more active in acquiring water for instream flows, but some private environmental groups have acquired rights for instream flow maintenance in several states (Colby, 1988 and 1990a; Saliba, 1987). For example, the Oregon Water Trust works to acquire water rights and commit those rights to instream flow maintenance to conserve fisheries and aquatic habitat and to enhance the ecological health of water courses (Bullitt Foundation, 1997). In general, its transactions are relatively small in scale, and most are targeted to benefit small tributaries with critical fish populations or other ecological values (Volkman, 1997).

On the whole, however, the role of market acquisitions in protecting stream flows has been limited. The relatively low level of market activity for flow protection is attributed in part to the fact that the transactions costs for this category of transfers are likely to be higher than for water rights purchased for diversionary uses (Colby, 1990a). The principal reasons for this are: offstream users usually oppose the acquisition of water rights for instream flow protection (Livingston, 1985); the incorporation of instream uses in the transfer review process makes it more complex and costly (Colby, McGinnis and Rait, 1991); and public agencies have little experience in handling transfers from diversion to instream uses (Colby, 1990a). In addition, instream users are interested in the level and duration of river flow, but a right to divert a given flow for a given period does not easily translate into a right to a certain depth at a certain location (Scott and Coustalin, 1995).

In addition, public and particularly private agencies potentially interested in acquiring water rights for flow protection may be reluctant to do so because of the fears that "water

transfers to the environment will not ... create increased water flows because pre-existing streamflow requirements will absorb the transfers" (Gray, 1996). The "Model Water Transfer Act for California", a business-sponsored proposal to facilitate and streamline water transfers in the state, addresses this problem by requiring that water that is transferred to instream uses is in addition to regulatory requirements governing water quality, instream flows, fish and wildlife, recreation, and other instream beneficial uses and that regulatory agencies and courts must exclude water transferred to instream uses from their determination of the amount of water required to comply with these regulatory requirements. Another concern is the capacity to monitor and enforce the rights to instream flows (Howe, 1988).

2. Principal issues

(a) The public goods aspects of instream flows

While off-stream water uses are typically for private goods production, there is often a high degree of non-excludability and non-subtractability associated with many instream uses, i.e., they are typically used for public and quasi-public goods production. Hydroelectricity generation and water transport are the main exceptions. A high degree of non-excludability both inflates demand for instream uses and constitutes an important impediment to private provision, because beneficiaries cannot be readily be charged a fee.

The public goods nature of instream uses provides a theoretical justification for a public role in the acquisition of water rights for streamflow protection. Government participation can complement private sector efforts to protect flows at adequate levels and desirable locations (Colby, 1990a). On this view, one of the best means of protecting instream flows would be to extend the capability to appropriate or purchase rights for instream uses to appropriate public bodies, especially local governments, as most of the benefits and losses generated by stream systems are local in their impact (Howe and Lee, 1983; Howe, Schurmeier and Shaw, 1986b; Howe, 1988 and 1996). For this reason, local governments "have an incentive to identify streams deserving protection, to provide funds to protect flow levels and to monitor and enforce flow standards"; they also have "a unique perspective on the trade-offs between retaining water instream and making it available for offstream uses" (Colby, 1990a).

As rights holders, however, public agencies, including local governments, present a number of problems. There is the risk that authorizing a public agency to use budgetary funds to acquire water rights could result in excessive amounts of water being dedicated to instream flows (Williams, 1985). In addition, there is the risk that such an agency, even well endowed financially, may be unable to respond quickly to changing market conditions and may be not as cognitive of the opportunity costs of holding onto its rights, as acutely as would a private entity (Anderson and Johnson, 1986; Williams, 1985). On the other hand, there are obvious economic limits to the public purchase of water rights, especially in the low-income areas; and the nature of public agencies may prevent them, for example, because of the political power of opposing interest groups, from acquiring the requisite number of rights (Livingston and Miller, 1986).

(b) Transfer externalities

The introduction of instream rights should not affect the rights of existing offstream users to continue using water in the same manner and place as before (Thompson, 1982). It

can reduce, however, the transferability of existing consumptive water rights from downstream to upstream users, which may introduce a potential for opportunistic behaviour aimed at extracting rents associated with upstream transfers (Anderson and Johnson, 1986). Transfer externalities are site specific and depend both on the degree to which the water course is appropriated, and the location of an instream water right in relation to diversion rights (Livingston and Miller, 1986).

(c) The need for coordination

The nonconsumptive nature of instream uses does not eliminate conflicts among them and between them and diversionary uses. Different instream and diversionary uses have different requirements for different but interdependent physical, biological and chemical attributes of streamflows which both vary in time and space, and are affected by water use and transfers.

Perhaps the most common complication arises with uses which rely on reservoir storage to allocate annual streamflow over time. For example, in many locations hydroelectricity generation competes with other water uses because it shapes streamflows to meet power demand that are often out of phase with the seasonal requirements for other uses (Huffaker, Whittlesey and Wandschneider, 1993). The coordination between offstream uses and instream recreational and environmental uses is also problematic because both compete for limited water, but each of them is interested in different dimensions of the water resource: offstream users care about diverted and consumed quantities, while instream users are interested in the level and duration of river flow and lake levels (Naeser and Smith, 1995; Griffin and Boadu, 1992).

In Chile, in order to overcome some of the difficulties involved in coordinating the instream and withdrawal uses of water, specific consideration has long been given to instream uses, culminating in the creation of "non-consumptive water rights" in the revisions to the water law embodied in the 1981 Water Code (see Box 6).

C. Area-of-origin effects

"Area-of-origin" effects or the economic, social, cultural and environmental impacts of water transfers on areas from which water is transferred. These effects have a particular implication for water markets because they have the potential of affecting the conditions under which transfers will be approved and the costs of implementing such transfers (Saliba and Bush, 1987). The most important of area-of-origin effects are the negative impacts on local economies and interference with the operation of water distribution systems. There may also be environmental effects, particularly if agricultural land goes out of use. A particular concern, expressed in the literature, is with rural to urban transfers which can threaten rural cultures and lifestyles.

Box 6

Consumptive and non-consumptive water rights in Chile

Under Chilean water law distinctions have always been made between various types of rights. In the revisions to the law embodied in the 1981 Water Code, a particular distinction is made between "consumptive rights", which entitle the holder to consume the water without any obligation to replenish it, and "non-consumptive rights", which entitle the holder to use or divert waters provided they are later returned to their original channel, without damaging the rights of third parties to the same waters in any way. The concept of non-consumptive rights was an extension for any instream use of the lesser rights, "*mercedes de fuerza motriz*", granted for hydroelectric power generation in earlier versions of the law.

While, as a general principle, the Water Code does not recognize any order of priority among water uses, it contains several provisions which maintain the subordination of non-consumptive rights to consumptive rights. Under it, owning a non-consumptive right does not imply, except by express agreement between the parties, any restrictions on the free disposal of consumptive rights. The Water Code also provides that non-consumptive water rights holders cannot detain the flow of water without permission from the consumptive rights holders, must avoid sudden surges and reductions of flow, and cannot prevent consumptive rights holders from modifying their canals or closing them for maintenance. The rules for exercising a non-consumptive right are determined in its formal act of acquisition or constitution.

The distinction between the two types of rights has not prevented conflicts over management of reservoir storage between power companies and farmers. These conflicts have centred around the interpretation of the provisions of the Water Code about the definition of non-consumptive rights and their relation to consumptive rights. Power companies have argued that, in their view, non-consumptive rights implicitly include the right to temporarily store water in reservoirs and to some degree of flow regulation, or it would defeat the whole purpose of hydroelectric development. Farmers are understandably concerned about the effects of storage and flow regulation on their consumptive rights. In some cases, farmers have found much of their water cut off during the peak of the irrigation season, while in other cases, the issue has been the timing of releases and their effects on downstream users. Farmers protest that the frequent, unpredictable fluctuation in the flows reaching their canals increase costs and make their water rights less valuable.

The failure to integrate non-consumptive rights holders into the user organizations, "*juntas de vigilancia*", responsible for water allocation, and the necessity to resort to judicial solutions have exacerbated the conflict between consumptive and non-consumptive users. The *juntas* decide on the allocation of water, but decisions within these organizations are made by majority vote and the member canals cast votes in proportion to their water rights. Since the law does not establish any proportionality between the two types of rights and there can be several non-consumptive water rights for each consumptive right, the non-consumptive users are likely to outnumber and outvote the consumptive users. For this reason, consumptive users tend not to invite non-consumptive ones to their meetings, in consequence the latter for their part tend to ignore the organizations. Thus, a useful forum for negotiation and a low-cost and expedient conflict resolution mechanism does not function effectively, and many conflicts have to go to the legal system, whose performance has been uneven.

Source: Bauer (1995b) and Figueroa del Río (1995).

1. Economic effects

The potential economic effects of water transfers are usually ignored in economic efficiency analysis on the grounds that they constitute "pecuniary" externalities and as such represent income redistribution rather than real welfare changes because: (i) any temporary unemployed resources will be able to move quickly and without undue cost to other uses; and (ii) since

transferring water to a higher-value use should generally result in an equally higher positive pecuniary externalities, any negative effects in the area-of-origin will be more than offset by the positive economic effects for the area-of-receipt. In addition, pecuniary externalities are hard to measure and their measurement has been subject to great abuse in justifying various projects (Howe and Goodman, 1995; McCarl *et al.*, 1997).

In practice, negative economic effects of water transfers on the area-of-origin appear to be small and can be often compensated by benefits in importing areas. For example, an evaluation of the 1991 California Drought Water Bank estimates that the income gains in agricultural regions that bought water were US$ 45 million, while losses in exporting areas, were US$ 13 million (Howitt, 1994). Employment impacts were equally positive. In Chile, rural to urban transfers have rarely resulted in negative effects in the exporting areas, because farmers usually sell small portions of their water rights and are able to maintain agricultural production by adopting more efficient on-farm irrigation technology (Rosegrant and Gazmuri, 1995).

Only in extreme cases are incompletely compensated effects likely to arise. The magnitude of economic impacts can be expected to vary with the size, suddenness and distance of the transfer, the characteristics of the area-of-origin and its economy, the use of the water sales proceeds, and the strength of the backward and forward linkages between agriculture and other local economic activities. For example, in Colorado, early transfers were local in nature, to higher-value, more employment-intensive uses within the same economic area (Howe, 1997b). They stimulated the local economy and the negative economic effects associated with the transfers were relatively small. Later transfers were larger, most of them interbasin, resulting in noticeably larger secondary regional impacts.

Real economic losses may occur in the presence of long-term, structural unemployment of resources, immobility of resources, and the existence of economies of scale in related economic sectors (Young and Haveman, 1985; Howe and Easter, 1971). Since rural and urban transfers often take place from depressed areas characterized by long-term unemployment of human and other mobile resources and there can be impediments to resource mobility, "pecuniary externalities usually involve some real costs that should not be ignored" (Howe, 1997b). In addition, income redistribution from rural exporting to urban importing areas may be undesirable from a policy standpoint (Nunn and Ingram, 1988).

It is in part for these reasons that some jurisdictions in the United States have adopted strong, perhaps excessive, policies to safeguard the needs of exporting communities. In Colorado, for example, Water Conservancy Districts that export water from the basin of the Colorado river and its tributaries are required to construct compensatory storage reservoirs in the basin of origin (Anderson, Maddox and Simmons, 1991). "This requirement has proved to be enormously wasteful and of little tangible benefit to the area of origin because most completed compensatory storage projects have stood unused" (Getches, 1988). Several states allow recapture of a share of the transferred water at a later date through a superseding priority that can be used to meet future area-of-origin needs (Anderson, Maddox and Simmons, 1991). Such restrictions discourages the out-of-basin transfers because of the uncertainty caused by making the acquisition of rights subject to some future, unquantified right of recapture. In Idaho, a statute provides that transfers from agricultural use should not be approved where such changes would significantly affect the agricultural base of the local area. Some states adopt a balancing approach of the benefits and detriments expected to result from a transfer authorizing it only if its benefits outweigh detriments to the originating basin. In Nebraska, for

example, interbasin transfers are deemed in the public interest if the overall benefits to the state and the applicant's basin are greater than or equal to the adverse impacts to the state and the basin of origin. In Montana, only the Department of Natural Resources and Conservation may appropriate water for export out of specified river basins, and the state may then lease such water for periods of up to 50 years.

Although these policies may seem excessive, some limited transitional assistance during periods of economic and social change could be warranted to help labour and capital move quickly and without undue hardship out of economic activities forced to contract by the transfer (Howe, Lazo and Weber, 1990). In addition, setting aside the question of economic efficiency, compensation to affected parties may be viewed as a practical policy tool that may reduce local resistance, facilitate the process of implementation, and reduce the transaction costs of implementing water transfers (McCarl *et al.*, 1997). It is important to note, however, that modern dynamic economies are characterized by intensive resource reallocation which is the source of much of economic growth. Governments do not generally provide protection from the indirect economic and social effects of resource reallocation decisions (Gould, 1989).

In considering any restrictions on water transfers, it is important to avoid protectionist policies which lock water into historic uses or specific locations and perpetuate antiquated water use patters that run contrary to efficient water allocation and modern demands, rather then encourage reallocation as economic and social conditions change. This inertial inefficiency is inconsistent with the notion of maximizing water contribution to aggregate welfare and can result into substantial economic losses.

2. Effects on water distribution systems

Water transfers can cause disruption and expense in adjusting distribution schedules and modifying diversion or distribution facilities (Clyde, 1989). Since all water rights used in the system are hydrologically interconnected, a sale of water rights to outside parties can make the other farmers bear a disproportionate share of the future seepage and conveyance losses and reduce the return flow available to downstream users. Even if the volume of water available for transfers out of the district system is defined on the basis of consumptive use, the reduction in the amount of water flowing through a system could increase the cost of water delivered to other farmers (Miller, 1987). This occurs, in part, because conveyance losses are not proportional to the quantity of water conveyed and because irrigation systems are often designed to facilitate the reuse of seepage from higher portions of the district's service area on lower parcels within the system.

A related concern is that if many rights are transferred, it can become difficult to finance system operation and maintenance costs (Easter, 1994). In the La Lagunera region of Mexico, for example, some water users organizations have developed a scheme to partially compensate the water user association losing the tariff income under which the buyer must pay 70% of the water tariff to the original association and 30% to the new association (Thobani, 1997).

Regulation of water transfers to outside parties should seek to balance the need to avoid any unreasonable impairment of the rights of remaining farmers, on the one hand, and the need to enable those who wish so to transfer their water rights to do so. These regulations often take the form of requiring a prior consent of a district to transfer water to a location outside its boundaries or other restrictions on individual water transfers. Miller (1987) has

shown that "these restrictions may be consistent with efficient water use and transfers" in cases where individually arranged transfers would impose negative externalities on other members of the district. In the United States, for example, in addition to receiving state approval, a transfer of water rights from a water district to lands outside the district boundary generally must receive prior approval of the district, while in the case of a mutual water or ditch company an approval by the board of directors may be required (Anderson, Maddox and Simmons, 1991).

3. Cultural effects

An important question for policy-makers is whether to take a passive role in allowing unrestrained water transfers from rural areas that have historically depended upon irrigated agriculture or to regulate these transfers with the view to protect rural cultures and lifestyles. On the whole, "it is completely legitimate for a society to protect cultural sub-groups through the reservation of water supplies. This is particularly true for cultures that centre on water" (Howe, 1997b).

There are several policy options, for example, protection may be provided by prohibiting permanent alienation of the water rights necessary for the preservation of important cultural values, but not temporal transfers. This approach has been implicitly adopted in the United States for the protection of reserved water rights accruing to Indian reservations of land. Alternatively, local authorities can protect cultural and social values through local zoning and land development regulations as to what type of development will be allowed or prohibited within their jurisdiction. The main disadvantage of these approaches is they are likely to result in the allocation that is rigid over time and unresponsive to changing economic and social conditions. One promising possibility is to vest the water rights in the community, rather than in individuals, letting the decision-making process at the community level to take cultural externalities into account when deciding whether or not water should be sold (Howe, 1997b), but this can lead to political concerns determining decisions rather than the operation of market forces (Williams, 1983). This kind of approach has been taken in Chile to the question of the water rights held by indigenous groups who do not accept individual ownership.

Although it is completely legitimate for a society to protect rural cultures and lifestyles, it is important to remember that plentiful water supplies do not by any means guarantee the achievement of these objectives. "Great care must be taken to avoid overselling the efficacy of water as a tool for solving what are essentially social problems that are more likely to be successfully dealt with by sustained and arduous collective efforts" (Young, 1986).

V. Distortions and market imperfections

One of the fears that is expressed in most discussions of water markets involves the degree to which water allocations maybe effected by the existence of market power, hoarding, speculation, and few transactions ("thin" markets). The traditional response to these fears has been the adoption of administrative restrictions, but the perverse incentives these provide have led to the consideration of new regulatory instruments which rely more on economic incentives.

A. Market power, speculation, hoarding and “thin” markets

1. Market power in a water market

Market power may be exercised in a water market in two ways: (i) directly, either through monopolistic behaviour as a price setting seller who sets price signals that are followed by other market participants or through monopsonistic behaviour as a price setting buyer; or (ii) indirectly where there is the potential for some economic agents to use control of water rights to exercise market power in the output market for the product for which water is an input.

(a) Monopolistic and monopsonistic behaviour

In any market, there exists the potential for some economic agents to influence market price levels or restrict transfers. Economic efficiency requires the presence in a market of a sufficient number of buyers and sellers so that the quantity of a good bought by any one buyer or sold by any one seller, relative to the total quantity traded, does not affect the market price. Where economic power is dispersed, no single market participant is in a position to exploit its market power to undermine competition and to gain unjustified advantage. As a result, buyers or sellers take the prevailing market price as given, i.e., act as "price takers". Where individual buying and selling decisions have a major impact on the price, prices may no longer reflect marginal values and they may cease to provide the market signals necessary for efficient resource allocation. Market power not only tends to reduce efficiency gains from market transfers, but may also have undesirable effects on the distribution of income (Brajer *et al.*, 1989). A large share of transferable property rights, however, does not necessarily mean having influence over the outcome in the market (Hahn, 1984).

In theory, but hardly in practice, large holders of water rights, often public utilities, might attempt to manipulate prices to improve their positions in the water market and to obtain "excess" profits. If there are few sellers, a seller with market power would follow a strategy resembling that of a monopolist, selling off, in any given time period, less than the quantity of water rights that would be sold in a competitive market, with the objective of forcing up the price above the competitive level, and hence earn larger profits at the expense of society as a whole. Such behaviour could stifle economic growth and create monopolistic profits for the sellers. Obviously, subsequent reselling of water rights would reduce monopoly power (Anderson and Johnson, 1986). In many cases, however, to execute monopoly power, it would be necessary to actually withhold the water which is extremely difficult, if not impossible, to achieve given its fugitive nature and probable limits on storage capacity.

If there are few buyers, a buyer with market power could follow a strategy resembling that of a monopsonist with the view to force down the price below the competitive level. In the

water sector, some monopsonists could also be monopolists in the output market (e.g., water-related public utilities). To counter the monopsonistic behaviour, sellers may decide to limit the number of actors on the supply side by participating in water markets at the wholesale level, for example, the irrigation district as a whole, rather than as individuals (Gardner, 1990). In the United States, in some cases, in response to plans for a major water purchase, farmers have negotiated jointly to ensure that all right holders had an equal opportunity to sell, that all sellers would receive the same price, and that the buyers would negotiate with interested farmers as a group so that collective interests could be considered (Saliba, 1987).

Studies of the empirical impact of market power on the cost-effectiveness of transferable discharge permit markets, which have a similar, if not more concentrated, structure than water markets, "are consistent with a finding that market power does not seem to have a large effect on regional control costs in most realistic situations ... Successful cartels are difficult to establish and maintain for any commodity ..." (Tietenberg, 1995). Rosegrant and Binswanger (1994) found that emerging water markets in developing countries are characterized by a great deal of competition, rather than monopolistic power.

Reputation effects may also be an important restraint. For example, evidence from water markets in the western United States suggests that high-visibility buyers of irrigation water rights, such as public utilities and businesses which are dominant actors in the regional economy, pay more per cubic meter for rights than other buyers (Colby, Crandall and Bush, 1993). The price premium may reflect various factors, but perhaps most important is the fact that many high-profile buyers are concerned with protecting their reputation and that of their shareholders' and may be inclined to pay somewhat higher prices for water rights to avoid the costs of negative public perceptions and to mitigate the controversy that often accompanies large agriculture-to-urban water transfers, both factors that could impose other costs on their activities in the basin and attract attention of regulatory authorities.

The potential for the accumulation of market power is greater in basins where unappropriated water exists along side rapid economic growth, especially if the original allocation of rights is free of charge and without any requirement that the water be put to a beneficial use (Howe, 1997b). In such systems, monopolization of supply can lead to substantial inefficiencies. In contrast, in the river basins where water is fully appropriated and there are many holders of rights (in Chile, for example, there are about 300 000 water rights holders (Faine, 1996)) and active water markets, the danger that monopolies or monopsonies will develop is relatively small (Howe, 1997b).

The possibility of monopolizing the market for water rights cannot be entirely ruled out, but for the most part, there is little danger of any single user dominating any basin to a degree that market competition is restricted. If market power posed a problem, however, the appropriate response is the application of general competition and antitrust or anti-monopoly policies. Restrictions on transfers, such as individual limits on ownership, may help prevent the emergence of market power, but they will also limit the flexibility of water users. Moreover, they are difficult to implement and could become a stifling influence on development. Other measures can be used to deal with the issue of market power, such as regulatory controls over transfers which seek to prevent the wholesale acquisition of available supplies without a demonstration of present or reasonably foreseeable need and the imposition of taxes for holding a water right without developing it within a reasonable time (Simpson, 1994b). The problem with the latter solution is establishing the form and level of the tax and not unfairly

penalizing those who have justifiable reasons for holding rights, while the former suffers from the same deficiencies as the beneficial use doctrine.

Another option is direct state participation in the water market, for example, as an intermediary, as with the California Draught Water Banks. Government probably has a legitimate role in helping mediate in situations where many small water users confront a dominant buyer or seller (Hamilton, Whittlesey and Halverson, 1989). Government operated water banks can help discourage attempts by large water rights holders to take advantage of water scarcity by speculating in water sales (Western Governors' Association, 1996).

If the emergence of market power is avoided in the initial allocation, there is little danger of the undue concentration of water rights in the hands of few colluding users. One reason, is the reluctance of water rights holders to engage in permanent transfers. In California, for example, the emphasis is on annual spot markets and emerging option markets (Howitt, 1997). In Chile, sales are still relatively infrequent in most areas.

(b) Market power in the output market

The second aspect of the market power problem - the potential for some economic agents to use water rights to exercise market power in the output market - is also a concern, but "there are reasons to doubt whether such strategies can be supported as equilibrium outcomes of market competition", instead incumbents would probably prefer to accommodate entry (Gilbert, 1989). There are few, if any industries, where water is a significant input, although there is little or no possibility for substitution in some important uses. Available water supply sources may differ in their characteristics, but all of them can substitute for one another to some extent. As a result, most potential users have a wide range of alternative supplies of water and alternative technologies. Users can substitute labour, management, or capital for water in many uses. In addition, many goods and services produced in the water sector are tradable, either nationally or internationally, and have a wide range of substitutes. When substitutes are available, competition arising from the threat of losing customers to substitute products and services, can discipline the conduct of rights holders. The main exception could be hydroelectricity generation, which suggests the need to develop an adequate regulatory framework and to avoid uncompensated and unconditional allocation of water rights. If any user were to follow a strategy designed to raise costs for potential competitors, it would be a question of fact as to whether they were engaging in illegal monopolistic practices and this is precisely the circumstance antitrust laws are designed to deal with.

For example in Chile, the Empresa Nacional de Electricidad S.A. (ENDESA) is the largest electricity generating company and also the largest owner of non-consumptive water rights holding more than half of issued rights (see Table 7). This has given rise to allegations that it "can obtain the monopoly equilibrium over time by postponing investment. New entrepreneurs will be unable to enter because they do not have the water rights to undertake the more efficient projects" (Bitran and Sáez, 1994). The Comisión Nacional de Energía, the entity in charge of regulation in the electric sector, has estimated that a delay in the implementation of a large hydroelectric project could increase tariffs by up to 20% (Peña, 1997). Prompted by these concerns, the anti-trust commission has recently recommended to the DGA not to grant to ENDESA a series of new non-consumptive water rights it had previously requested (El Diario, 1997).

Table 7

Non-consumptive water rights in Chile

	In use		Granted but not used		Total	
	m³/sec	(%)	m³/sec	(%)	m³/sec	(%)
Large electric utilities						
- ENDESA	1 013	59.6	6 583	58.8	7 596	25.3
- CHILGENER	121	7.1	1 579	14.1	1 700	5.7
- COLBUN	190	11.2	-	-	190	0.6
Others	375	22.1	3 041	27.1	3 416	11.4
Total	**1 699**	**100.0**	**11 203**	**100.0**	**12 902**	**43.0**
Estimated potentially usable flow	**-**	**-**	**-**	**-**	**30 000**	**100.0**

Source: Chile/MOP/DGA (undated).

2. Other market imperfections

(a) "Thin" markets

Optimally, markets involve a relatively large set of transactions taking place continuously over time. A large number of buyers and sellers is an important condition for a stable and smoothly functioning water market. Thin markets, markets in which trades are few and far between, are common in water rights. In contrast to large, active markets where buyers or sellers take the prevailing price as given, in thin markets, prices must be negotiated case by case (Saleth, Braden and Eheart, 1991). Thus, thin markets are characterized by bargaining rather than competitive conditions. "In a bargaining environment, allocational efficiency depends critically on the relative bargaining strengths of the participants as determined by the bargaining environment" (Saleth and Braden, 1995).

In a thin market, search, information and negotiation costs may be very large (Crouter, 1987; Colby, Crandall and Bush, 1993). In addition, a thin market, where each transaction is unique and negotiated on a case-by-case basis, is likely to be less effective in setting a price that accurately signals the value of water and transmitting this and other information to market participants. "Specifically, when there are few potential traders, or traders are highly disparate in size, the linkages and information flows within a market may be inadequately developed and a common unit price will not emerge" (Clearwater Consulting Corporation, 1997). In a market with few transactions, demand and supply conditions can change quickly resulting in price volatility which increases price risk, reduces incentives to engage in trading and encourages hoarding (Tietenberg, 1995). A small number of participants makes any market more susceptible to manipulation by participants making it easier to establish and exercise market power leading to inefficiency and limiting the efficiency gains from water exchanges. Carefully designed bargaining rules can facilitate the efficient operation of a thin water market and

reduce the efficiency losses due to strategic bargaining behaviour (Saleth, Braden and Eheart, 1991; Saleth and Braden, 1995).

(b) Speculation

One of the most common concerns about unregulated water markets is the danger of speculation in water rights. Speculators are, however, an essential ingredient in any market. Their participation can help deepen and widen the market, thereby facilitating a key market function - the establishment of a "going" price. Small-scale speculation, carried out by a large number of water rights holders in "highly developed systems is useful and probably cannot by prevented", because it facilitates communication of water availabilities and prices, and improves market performance (Howe, 1997b). While speculators can play a useful role, it is as inappropriate to leave important water resource management decisions solely to their forecasting abilities, as it is to those of bureaucrats.

Under full transferability, mistaken decisions are costly for a speculator, while those who decide correctly are rewarded. If speculators persist in holding water rights longer then necessary, they incur substantial opportunity costs, since they must forego not only the benefits that they could enjoy from the proceeds of the rejected opportunity to sell, but also the income that they could earn by investing those funds. So speculators are constantly trading off the present value of a future sale against the present value of a current sale (Williams, 1983). It is also sometimes argued that speculation gives future users and consumers a voice, albeit an indirect and limited one, in the market place (Anderson, 1985). To succeed, speculators must have superior foresight in choosing their timing. Natural selection confines to a small portion of the market all would-be speculators except these few (Williams, 1983).

On the whole, in a free market, the possibility that speculation might distort prices through unequal bargaining power or monopoly control cannot be ruled out, particularly where water rights are granted free of charge in basins with a large number of unappropriated water rights and rapid demand growth. In developed market systems with fully appropriated water rights by many water users, these fears are probably exaggerated. In Chile, for example, according to Bauer (1997), the concern about speculation has been exaggerated in the case of consumptive rights, where agriculture accounts for the bulk of transactions, although speculation or hoarding "seems to have had a significant impact" in the holding of non-consumptive rights.

(c) Hoarding

Hoarding occurs when water users instead of selling water rights, accumulate and retain them for possible future use. It has a number of negative consequences. Hoarding results in thinner markets and fewer trades than might otherwise have been possible, and hence may act to reduce the overall economic benefits of water markets.

"Hoarding is a response to risk and it intensifies the very problem to which it is a response" (Tietenberg, 1995). Faced with the risk that in the future water rights might not be available for sale or lease or that their price might rapidly increase, water rights holders retain their rights for possible future use (e.g., if they decide to expand operations or some future unanticipated event, such as a drought, makes them vulnerable to water shortages). This means that reducing the risk associated with the availability and price of future water rights

mitigates against the occurrence of hoarding. "Greater security translates into a greater willingness to sell" (Tietenberg, 1995).

Examples of public policies than can be used to reduce these risks, and hence remove the motivations that give rise to hoarding behaviour, include: (i) the policies aimed at broadening the market and providing a large number of participants on both the buyer and the seller side of the market (demand and supply conditions tend to be more stable in markets with a large number of buyers and sellers, while thin markets are often characterized by higher price and availability risks); (ii) the development of storage facilities and interconnected conveyance systems; and (iii) the development of active spot, forward and futures markets. Forward and futures water markets permit water users to hedge against changes in the price and availability of water rights, and thus eliminate the need to hoard as a hedge against this risk.

B. Alternative public policies to deal with the problems of market power, speculation and hoarding

1. The appurtenancy rule

Attachment ("appurtenancy") of water rights to a specific parcel of land forms part of many water rights systems, particularly, under the riparian system, where the right to use and enjoy water emerges from a person's ownership of land touching a watercourse, but also in other systems, such as those of the provinces of Mendoza and San Juan in Argentina. A common justification for attaching water rights to land is to prevent speculation. The implications of the appurtenancy rule for water allocation are relatively small when water is abundant and trade-offs are unnecessary, but its limitations became increasingly evident when water becomes scarce and non-adjacent lands develop needs for water. Where water is, however, not as plentiful or where water quality problems are important, it "simply does not work" (Howe, 1996).

Although, in general, the appurtenancy rule does not encourage water reallocation, its implications for water markets depend on its actual implementation (Saliba and Bush, 1987). In those jurisdictions where the appurtenancy rule permanently attaches a right to use water to a particular parcel of land and allows water to be transferred only if the buyer purchases the land to which the rights are attached, it hinders the development of separate land and water markets (Crouter, 1987). This is inefficient because it unnecessary links land, an immobile stock resource, to water, a mobile, flow resource, thereby limiting the potential uses of both resources. Water is a factor of production for various sectors and, for this reason alone, it should be transferable separately from land. The appurtenancy rule hinders an efficient and equitable allocation of water rights, severely limits opportunities for market transactions, makes them more costly and complex, and increases the costs of meeting water needs in other areas.

In the jurisdictions which prohibit the sale of water exclusive of the land to which it is tied, the practice has built up of transferring water through complicated land exchanges, which are incidental to the real purpose of the transaction - acquisition of water rights. Land may be acquired for the sole purpose of obtaining the accompanying water rights, known as "water ranching", as in the United States. Such practices were also common in Australia where, before permanent transfers of water rights through markets were liberalized in the eighties, farmers transferred water entitlements through "duality of ownership" or "licence stacking"

which involved purchasing two parcels of land and transferring the water entitlement from one to the other (Anderson and Snyder, 1997).

Where the appurtenancy rule is interpreted as simply requiring that to change the point of diversion or location of use, a transfer application must be approved by the appropriate public agency, its effects on market transfers are generally innocuous. Such a requirement generally imposes only minor transaction costs on market participants (Saliba and Bush, 1987).

In many parts of Latin America, the appurtenancy principle inherited from Spanish law is still adhered to (ECOSOC, 1996). In some areas, such as in western Argentina, the appurtenancy principle, restricts the transfer of water both intra- and inter-sectorally, and, in association with other factors, "has made a noticeable contribution to the stagnation and even regression of regional economies" (ECOSOC, 1996). In the province of Mendoza, for example, water rights are tied to land and changes in the source of supply are not allowed, expect in very special cases, resulting in a rigid system of water allocation which is incompatible with rational and efficient use (Bertranou *et al.*, 1987). A recent study of water resources management in the province recommended to make surface water rights for irrigation tradable among water users and to allow temporal and permanent water rights transfers (Howe, 1997a).

2. The beneficial use doctrine

In most jurisdictions, traditionally, the allocation and retention of non-riparian water rights are contingent upon putting them to some beneficial use. A typical formulation of the rule of beneficial use, as applied in the United States, is that beneficial use is the basis, measure and limit of all rights to the use of water, consistent with the interest of the public in the best utilization of water supplies. In 1981, Chile departed from the beneficial use exigency, and this is proposed in the new water law under discussion in Peru and in similar proposals in some other countries of the region.

The beneficial use doctrine emerged when unappropriated water existed along side rapid economic growth. Without the obligation to apply water beneficially, the first user on a stream could lay claim to all the water. This is obviously impossible on fully appropriated streams. The idea behind the requirement was that the quantity of water used should be no more than needed, the concern being with the possibility of vesting an absolute monopoly on a single water user and preventing speculation. It is often summarized as the "use it or lose it" principle. The tenets of the doctrine of effective and beneficial use are: water is not to be obtained for speculation or let run to waste, the end use must be a generally recognized and socially acceptable use; water is not to be misused, and the use must be reasonable compared with other uses (ECOSOC, 1996).

Under forfeiture and abandonment provisions of the beneficial use doctrine, a right can be lost and become available for appropriation by others after a period, typically three to five years of continuous non-beneficial use, when water is over-applied and not used beneficially for a certain time period, due to intent to abandon the right, or when the right has fallen into complete disuse. If not used, the right ultimately reverts to the reallocation through the state. This is the general approach adopted under laws of the United States, Argentina, Mexico and Spain (Solanes, 1996). The water needs of the projects that take a longer time to complete can be accommodated with the help of conditional water rights. In the state of Colorado, for

example, in order to maintain a conditional water right, an applicant must demonstrate reasonable diligence in developing the right, every six years from the date the right is awarded.

The beneficial use doctrine has important implications for water marketing in that it defines those water uses that can participate in market transfers, i.e., those water uses for which water rights can be granted by the State in the initial allocation of rights or acquired in a market transaction. Water uses which have not been declared beneficial cannot hold water rights and cannot participate in water marketing. The declaration that a potential use is beneficial serves, therefore, as an "entry point" into the market process (Colby, 1988). Obviously, this requirement reduces the number of potential market participants to those few who can put water to immediate use, and hence competition in the market. Thus, its abolition is likely to increase the number of potential current buyers, and thereby stimulate market activity.

The application of the beneficial use doctrine can provide water rights holders with an incentive to transfer their water rights rather than hoard them and risk forfeiture under forfeiture and abandonment laws. Its impact on incentives to transfer or use rather than hoard water rights depends, however, on the monitoring, implementation and enforcement procedures. The problem with this approach is that the doctrine discourages hoarding administratively but fails to address the rational motivations that give rise to hoarding behaviour. The transferability of water rights in the market can provide a more direct incentive to both avoid waste and to reallocate water to its highest value use in response to changing conditions. In an open market, water users failing to sell their water rights forego the proceeds from those sales and the income that could be earned by investing these funds. Thus, "when rights are fully transferable, there is no need for a horde of government agents to snoop about and uncover waste. There is no need for laws to prohibit waste or for courts to define it" (Williams, 1985).

The fear is often expressed that without the penalty of forfeiture for non-use, the incentives for large water rights holders to transfer water rights, would be relatively small compared with the strategic advantages from the control of a key production input which could be used to block entry (ECOSOC, 1996). In most settings, however, there is little danger of any single user dominating a basin to a degree that market competition is impossible and even if this were to occur, more flexible and market-compatible policy options are available to deal with this problem. It is also claimed that the beneficial use doctrine is necessary to prevent the so-called "sleeper" or unused rights, which introduce uncertainty into the system of water use and reallocation (Livingston, 1993).

Whatever its historical justification, the beneficial use doctrine has important drawbacks from the point of view of economic efficiency. In highly developed systems where water is fully appropriated by many water users, it is probably unnecessary and its continuation does not encourage efficient water development and utilization. It can be expected that the application of the doctrine will gradually fade away (Scott and Coustalin, 1995). The doctrine has already been relaxed in many jurisdictions - in the state of Colorado, it has been said that, "the only use ever ruled nonbeneficial by a water court was a diversion used to drown praire dog colonies on a ranch" (Howe, Schurmeier and Shaw, 1986b) - to make it more compatible with the need to encourage conservation and promote flexibility in water allocation. This was necessary because in some instances, sale of a water right had been interpreted as evidence that its owner could no longer put the water to beneficial use (Frederick and Kneese, 1988).

The beneficial use doctrine is sometimes criticized because it is difficult to define what constitutes "beneficial" use "with any degree of precision, as any level of beneficial use is

permissible" (Anderson, 1961). Whatever be the case, the definition of what constitutes "beneficial" use must be adaptable to changing economic needs and social values (Howe, 1997b). It should be broad enough to include all uses, both offstream and instream, that generate social benefits. It should also be formulated in such a way so as not to introduce uncertainty in the water allocation process and should not contain preferences or priories of use, except those to be applied in time of severe water shortages with a provision for adequate compensation.

The beneficial use doctrine can, also, be criticized on the grounds that it encourages wasteful expenditure of resources (Williams, 1985). Since under the beneficial use doctrine, those water users who anticipate future profitable water-related projects cannot hold rights for future sale or use, there is an incentive to invest prematurely in facilities for an immediate use recognized as beneficial. These investments may be economically attractive only because they secure water rights for the future or transfer them from the public to the private domain. As a result, these is an incentive for water rights holders to disguise their future needs with investments that are economically unjustifiable or premature. Similarly, the beneficial use doctrine can reduce incentives to engage in "speculation" and "hoarding", but does not prevent speculation, rather it forces the would-be speculators to disguise their activity by wasting resources in the construction of diversion works that are either economically unjustifiable regardless of their timing or are premature. Inefficiencies can also arise when water rights holders use more water than they can presently use profitably in order to protect the security of their rights, to assure additional supplies for the future, or establish a right to the use of such water in the future when the use might become profitable (Burness and Quirk, 1979). The result is the excessive use of water and the realization of investments sooner than is necessary. A related problem is the disincentive provided for water conservation and for the transfer of salvaged water.

To protect against the disincentive the doctrine provides to efficient water use, state water laws in the United States usually limit water rights to diversions that qualify as "beneficial consumptive use" or to the amount of water "reasonably" required for the use to be served, and prohibit waste, misuse or unreasonable use of water. The beneficial use, anti-waste provisions, however, were "never enforced to the stringency necessary to promote efficiency" (Anderson, Maddox and Simmons, 1991).

Where there are active water markets, the beneficial use doctrine is probably unnecessary, but it can probably be justified as a transitory measure in some settings, particularly in basins with a large number of unappropriated water rights and rapid demand growth. In jurisdictions where water rights are granted free of charge, the requirement of beneficial use could be necessary in so far as it can help prevent frivolous claims on all unappropriated water, and speculation sustained on the hoarding and accumulation of non-used water rights.

3. Taxes

One possible way to address the problems of market power, speculation and hoarding within the framework of voluntary water transfers is to introduce a tax on water rights holdings. Water rights would be appraised and taxed separately from land and other resources. The tax rate should not depend on the purpose for which the water is used, but only on the type of water right. This means that the introduction of a tax on water rights should generally be accompanied by a corresponding adjustment of land taxes and other similar taxes on irrigated land.

Such a tax has many desirable consequences. By raising the cost of water, taxing water rights separately from land discourages both the acquisition of water rights without intention to put them to a beneficial use and their hoarding, and provides a strong incentive for water rights holders to transfer unused rights in order to reduce their tax burden. It also fosters market discipline and efficiency, accelerates water reallocation, both intra- and inter-sectoral, to higher-value uses, promotes conservation, provides incentives for more efficient water use and allocation, and, in sum, encourages water rights holders to manage water as an economic good, rather than as a free attribute of land ownership. Other important advantages of the tax approach is that for governments, the ability to collect an annual tax would make it possible to generate considerable revenue that could be used to finance the surveillance, record-keeping, enforcement and other regulatory efforts necessary to run the system. It could also be used to compensate negative externalities associated with water transfers or to finance river basin management activities with strong positive externalities or public goods characteristics. A tax on water rights would also give the government the incentive to register and regularize all water rights.

The main problems with taxes are that: (i) the determination of the optimal rate is fraught with non-trivial difficulties, while tax rates must be estimated accurately from the very beginning because they are not always easy to change; (ii) if the rate is too low, the tax would not achieve its purpose, and if it is too high, the tax would unduly penalize water users and can discourage investments; (iii) taxes on inputs tend to be more difficult to define and easier to evade than taxes on outputs; and (iv) taxes are unpopular and are likely to resisted (Pearce, 1989). The institutional costs of implementing a system of taxes are likely to be high, particularly where there many water rights holders. This kind of considerations have prevented the introduction of specific taxes on water rights in Chile. The result is, however, that only farmers pay, at least implicitly, taxes on the water right, as irrigated land has a higher value and, therefore, higher land taxes. One of the proposed reforms to the 1991 Water Code calls for the introduction of a license or fee ("patente") for non-use (Peña, 1997). The approach is modelled after a similar concept in Chilean mining law: a concessionaire must either make actual use of the right to develop the mining concession, or pay an annual fee to maintain it.

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