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Principles and examples for the allocation of scarce water resources among economic sectors

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SUMMARY- Water resources have been usually allocated to ensure sufficient quantity for human consumption and food production, addressing mainly equity issues. Considerations of efficiency have not always been incorporated. Water scarcity and quality have become a major problem in many countries that are beginning to appreciate water as an economic good. This paper addresses some of the principles of allocating scarce water resources among sectors. Several allocation mechanisms such as marginal cost pricing, allocation by a social planning (public allocation), and allocation by market forces are described. Examples of these mechanisms are provided and advantages and disadvantages are discussed. The paper also offers examples of how countries within the Mediterranean littoral put economic principles in the allocation of water into effect.

Key words: economic efficiency, equity, water allocation, water pricing, marginal cost pricing, water markets, water resources development, water management

In the past several years, various international declarations and agreements have focused on or called for an approach to water resources management that is "comprehensive" or "integrated" or "holistic." Indeed, the 1992 United Nations Conference on Environment and Development in Rio de Janeiro advocated that comprehensive management of water be high on the agenda of all countries attending: "The holistic management of freshwater as a finite and vulnerable resource, and the integration of sectorial water plans and programmes within the framework of national economic and social policy, are of paramount importance for action in the 1990s and beyond" (UNDP 1994 p.71). That document goes on to say that "In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems. Beyond these requirements, however, water users should be charged appropriately" (UNDP 1994 p.71). Water, these agreements make clear, should be viewed as a social *and* an economic good.

Water resources have been allocated from the earliest times on the basis of social criteria--maintaining the community by ensuring that water for human consumption, for sanitation, and for the production of food is available. Societies invested capital in infrastructure to maintain this allocation. Yet change in societies, including change and development of understanding of how goods are distributed, has resulted in new issues for water and for its allocation. Population growth has made water scarcity a major problem in many countries, and pollution, while by no means a recent problem, is more widespread today than ever before in history. In this context, just what does it mean to treat water as an economic good?

What are some of the principles that can govern the allocation of water as an economic good? What does it mean to "charge appropriately?"

This paper addresses some of the basic principles of treating water as an economic good and of allocating it among sectors. It also offers examples of how some countries, both within and outside the Mediterranean littoral, could put economic principles in the allocation of water into effect. First, placing the use of these principles in the context of a national strategy that follows economic development goals is emphasized. Second, the paper outlines the economic principles of scarce resource allocation. Third, actual means of water allocation, including marginal cost pricing, social planning, and water markets, are reviewed. Finally, the paper gives some examples of experience with water allocation from several countries.

THE CONTEXT OF ECONOMICS IN WATER ALLOCATION

While the countries attending conferences such as the "Earth Summit" in Rio and the more recent Ministerial Conference on Drinking Water and Environmental Sanitation in Noordwijk (the Netherlands) endorsed both the treatment of water as an economic good and the use of economic principles in its allocation, these endorsements are accompanied by the need to put water resources management in the framework of national economic and social policy. The use of economic principles to allocate water should be a stated part of national water resources policies, strategies, or plans. The principles themselves need to have this type of top-level commitment to be used throughout the day-to-day management and allocation of water. Moreover, if these principles are to be used, countries should make the commitment to developing and supporting the institutions and individuals that will be putting these principles into action.

ECONOMIC PRINCIPLES OF SCARCE RESOURCE ALLOCATION

Water resources that comprise surface water (rivers, lakes, and reservoirs), groundwater, floodwater, and, with the advent of new technologies, desalinated water, are an essential input for various economic sectors, such as municipal, industrial, agricultural, hydropower, recreation and environmental. With growing population rates, improved life style, and dwindling supplies (both in terms of quantity and quality), the competition over scarce water resources is increasing. It is thus of increasing importance that the existing water resources be allocated more efficiently. It is therefore necessary to make economic decisions compatible with social objectives, that is efficiency and equity considerations. While economic efficiency is concerned with the amount of wealth that can be generated by a given resource base, equity deals with the distribution of the total wealth among the society sectors and individuals. Many forms of water allocation attempt to combine both efficiency and equity principles.

Economic Efficiency

Allocation of water to different sectors can be viewed from a purely economic point of view like a portfolio of investment projects: water is the limited capital, and the economic sectors use the capital and produce returns. In an economically efficient resource allocation, the marginal benefit from the use of the resource should be equal across sectors (that is, uses) in order to maximize social welfare. In other words, the benefit from using one additional unit of the resource in one sector should be the same as it is in any other sector. If not, society would benefit by allocating water to the sector where the benefits, or returns, will be highest. Another definition of economically efficient allocation is *Pareto Optimality*. According to this definition, an allocation of a scarce resource is efficient if and only if no user could be made better of without making someone else worse off.

Equity

Resource allocation may also be based on equity. Equity objectives are particularly concerned with fairness of allocation across economically disparate groups, and may or may not be consistent with efficiency objectives. In the case of household water, for example, an equitable allocation of water resources suggests that all households, regardless of their ability to purchase water, still have a basic right to water services. Meeting this objective may entail providing government subsidies or free service, or perhaps adopting a differential pricing structure based on income.

Criteria for Allocation

Appropriate means of resource allocation are necessary to achieve optimal allocation of the resource. There are several criteria used to compare forms of water allocation (Howe et al. 1986):

- *Flexibility* in the allocation of existing supplies, so that the resource can be shifted from use to use, place to place, as demand changes, thus allowing to equate marginal values over many uses;

- *Security* of tenure for established users, so that they will take necessary measures to use the resource efficiently; security does not conflict with flexibility as long as there is a reserve of the resource available to meet unexpected demands;

- *Real opportunity cost* of providing the resource is paid by the users, so that other demand or externality effects are taken into consideration. This allows the allocation to account for environmental uses with a non market value (such as providing a habitat for wildlife). This also directs the employment of the resource to activities with the highest alternative values;

- *Predictability* of the outcome of the allocation process, so that uncertainty (especially for transaction costs) is minimized;

- *Equity* of the allocation process should be perceived by the prospective users, providing equal opportunity gains from the resource to every potential user;

- *Political and public acceptability,* so that the allocation serves values and objectives of various segments in society;

These criteria, frequently invoked in many water policy debates on the need for equity or fairness in water allocation, and whether or not these criteria are relevant in the case of water. An additional set of criteria should include (Winpenny 1994):

- *Efficacy*, so that the form of allocation changes existing situation and drives towards policy goals

- Administrative feasibility and sustainability, to be able to implement the allocation mechanism, and to allow a continuing and growing effect of the policy.

Tradition of Government Involvement

Water has traditionally been provided to meet demand with substantial involvement of governments. Allocation by governments (usually referred to as public allocation, or a "social planning" allocation) has usually not addressed economic efficiency, but has been necessary because of several features that distinguish water from other scarce resources.

What is so unique about water? It has several characteristics that make the role of the public sector in its development and management more essential than for other goods that can be handled efficiently in a market framework. For example, some water services are public goods, that is, their provision to one individual does not eliminate other individuals from using it. The lack of beneficiary identification may cause under-investment, misallocation of the resource, and negative externality effects among the potential users, leading to market failure. Other services are characterized by economies of scale, that is, the average cost decreases as more units are produced. This may create monopolistic power and socially inefficient allocation, leading to market failure. Water projects are usually associated with large volumes of investment; most capital markets do not have the capacity to finance such huge investments over the necessary time period. Because of the range of market failures and the large volume of capital needed for water projects, a significant share of water-related infrastructure investments are conducted by the public sector (World Bank 1993). In some cases, water allocation is used by governments to promote agrarian reform goals, so that additional objectives, such as income redistribution, settlement of remote regions, or food security enter the social welfare equation. For these reasons, public (government) allocation of water is still the main mechanism in many countries.

The objectives of water resources policy and the criteria for the allocation of water can be targeted via numerous forms of allocation, ranging from complete control by the government to a mixture of market and government allocation, to predominantly market allocation (even the latter, however, requires government support and intervention as explained above). Since countries and circumstances vary widely, allocation within any country can be regarded as a unique system for sharing the available water supply across the known sources of demand. The structure of any particular system of water allocation is of course influenced by the existing institutional and legal frameworks as well as the water resources infrastructure. Indeed, some forms of allocation are likely to require a specific set of laws and regulations, organizations, and water resources infrastructure to operate effectively.

The major forms of allocation, however, are relatively few, and the next section identifies several of them, together with their major advantages, and disadvantages.

WATER ALLOCATION MECHANISMS

This section discusses the concepts, advantages, and disadvantages of three water allocation mechanisms: marginal cost pricing, public allocation, and water markets. Table 1 compares these mechanisms according to the criteria outlined above.

Marginal cost pricing

A marginal cost pricing (MCP) mechanism, in essence, targets a price for water to equal the marginal cost of supplying the last unit of that water. An allocation which equates water's unit price (the marginal value of water) with the marginal cost is considered an economically efficient, or socially optimal, allocation of water resources. The efficiency criterion maximizes the total value of production across all affected sectors of the economy.

Water supply costs typically include collection, transport to a treatment plant, water treatment to meet quality standards, and distribution to customers (Spulber and Sabbaghi 1994). Water costs typically do not include headworks, which should be included. Water costs may also include any social costs, although they may be more difficult to calculate. If there are higher costs to allocate water to some uses than to others, then the price can be differentiated to be equivalent to the relevant marginal cost of provision to each type of use (Tietenberg 1988, p.206; Spulber and Sabbaghi 1994). MCP can be applied also to develop differential prices for different qualities of water where higher-quality water has a higher marginal cost of provision (Spulber and Sabbaghi 1994, p.224).

Advantages

The most obvious advantage of MCP is that it is theoretically efficient. Not only are the marginal costs and benefits equal, but at the efficient price--the difference between the total value of water supplied and the total cost--is at a maximum. MCP avoids the tendency to underprice (and consequently overuse) water. Under conditions of scarcity, excessive water use is obviously undesirable and comes at a high social cost. A MCP system could avert overuse because prices would rise to reflect the relative scarcity of water supplied.

Disadvantages

The principle limitation of MCP relates to difficulties in defining marginal cost itself (Saunders et. al 1977). These difficulties are in part a result of problems in collecting sufficient information to correctly estimate and subsequently monitor benefits and costs. Spulber and Sabbaghi (1994) note the following definitional problems:

- The marginal cost is multi-dimensional in nature.
- The marginal cost varies with the period over which it is measured, that is short-run vs. long-run marginal cost.
- The marginal cost varies depending upon whether a demand increment is permanent or temporary.
- The marginal cost varies depending upon the length of forewarning which an enterprise has of a demand change.

These issues, among others, create considerable difficulties in selecting a short-run (SRMC) or long-run marginal cost (LRMC) figure in establishing price. Simply put, when existing supply is fully utilized, water providers must invest huge sums in developing further capacity. If MCP is strictly applied, then the high cost of expanding water supply (new reservoirs and pipes, for example) results in a "bump" in the marginal cost function of the water provider which stabilizes only after the recovery of the large fixed costs.

MCP is also disadvantageous because it tends to neglect equity issues. In periods of shortage or scarcity, if prices increase to the necessary level, lower income groups may be negatively affected. Equalization is intended to address potential inequity when marginal costs push water prices beyond the affordability of lower income groups.

At a more practical level, MCP is difficult to implement because it requires volumetric monitoring, which is very costly and difficult to administer. Also, MCP concepts are frequently poorly understood by those involved in policymaking and administration (UN 1980).

Public Water Allocation

Three main points support the argument for public or government intervention in the development and allocation of water resources: it is difficult to treat water like most market goods, water is broadly perceived as a public good, and large-scale water development is generally too expensive for the private sector. The list in Box 1 details the characteristics of water that establish a role for government intervention and action in water allocation.

Box 1 makes clear that there is no single objective to a public water allocation mechanism. Although a national or state agency may consider MCP approach, public water allocation mechanisms are far more likely to be preoccupied with equity, sovereignty, and an overwhelming concern with satisfying the greater public good. Ideally, these objectives and the efficiency objectives produced by MCP would be met simultaneously. In practice, public water allocation mechanisms typically consist of various inefficient water pricing schemes. Flat-rates/ fixed charges are common, easy to manage and easy for users to understand. Other rate schedules are often based either upon a minimum charge or a fixed charge. These charges are often accompanied by either volume charges, seasonal rates, or an increasing or decreasing block rate.

Box 1: The Case for Government Involvement in Water Management.

Water has several distinguishing features that can define a role for public action:

- Large, lumpy capital requirements and economies of scale in water infrastructure tend to create natural monopolies, warranting regulation to prevent overpricing. Moreover, many water investments produce joint products, such as recreation, electric power, flood control, and irrigation, which make pricing and allocation decisions difficult.
- The large size and extremely long time horizons of some investments, given underdeveloped capital markets and the potential for political interference in many water infrastructure investments, reduce incentives for private investments in the sector.
- The uses of water within a river basin or aquifer are interdependent. Withdrawals in one part of the basin reduce the availability of water for other users; groundwater pumping by one user may lower the water table and increase pumping costs for all users; and pollution by one user affects others in the basin, especially those located downstream. These interdependencies suggest that having all users agree to the rules of the game--or lacking that, imposing government regulations, taxes, or both-could improve the social value of water resources.
- Certain aspects of water activities, such as the control of floods and waterborne diseases, are (local) public goods, which cannot easily be charged for on the basis of individual use. In such cases, public initiative may be required to ensure that levels of investment are appropriate.
- Water resources are often developed because of their strategic importance for national security and for regional development. Governments thus typically maintain ownership of water thoroughfares, providing services such as the coast guard and traffic regulation. Some regions are subject to periodic droughts. Because water is essential to sustaining life, governments may take control of water.

Source: World Bank 1993.

Moreover, the physical allocation of water among the users is independent of the charge. Allocation rules in this case can be based on historical facts (such as prior rights), on equal shares in available water volumes, on individual requirements, or even based on political pressure.

Advantages

Public allocation might be said to promote equity objectives, that is, ensuring water supply to areas of insufficient quantity. It can protect the poor, sustain environmental needs, and provide a given level of water to meet minimal needs in the receiving sector.

Disadvantages

Supplying water to deficient areas leads to expensive, publicly financed water projects which preclude any need to purchase water rights based upon the scarcity of the resource. In other words, subsidized water supply development replaces market mechanisms of water supply via transfers of water titles. Prices, as a result, do not represent either the cost of water supply or its value to the user. Publicly-mandated penalties can fail to incorporate the value of numerous goods and services which are either difficult to price or are not bought and sold.

As a result, public allocation mechanisms often lead to waste and misallocation of water, as well as fragmented investment and management of the existing resource. Also, public allocation often does not support user participation. In many cases, these results contradict the original policy goals in the basis of the public intervention.

Water Markets

In the following discussion, a market-based allocation of water is referred to as an exchange of water-use rights, compared to a temporary exchange of a given quantity of water between neighbouring users. The latter one is called spot water market, and operates some times under different set of rules than a water market.

From a strictly economic point of view, the operation of a (competitive) market has several conditions. First, the market should have many identical sellers and buyers, each with complete information on the market rules (institutions), and each facing similar transaction costs. Second, decisions made by each seller or buyer are independent of decisions made by other sellers and buyers. Third, decisions made by one individual should not affect the outcome of another individual. And, finally, the individuals (or economic agents operating in a competitive market are motivated to maximize their profits. Under such conditions, demand and supply forces dictate the quantities to be traded and the unit price for the commodity in this market. Usually, commodities (resources) will move from their uses at low value to highest values. Therefore, market-based allocation is considered economically efficient from an individual and social point of view.

In the case of water, there are several additional stipulations resulting from the special characteristics of water that have been discussed earlier. Sometimes it requires intervention of government to create necessary conditions for market to operate. This includes (1) defining the original allocation of water rights, (2) creating the institutional and legal frameworks for trade, and (3) investing in basic necessary infrastructure to allow water transfers.

The market mechanism, if operated under such conditions could secure water supply for high-value uses in various sectors without the need to develop new, costly water resources. Also, by allowing compensation for water sold by low-value uses, water markets provide an incentive for more efficient water use.

Advantages

Water markets provide several benefits. The seller has an opportunity under certain conditions to increase profitability (except if all water resources are sold and the seller ceases economic activity). The buyer benefits because the water market encourages increasing water availability. In the case of water trade between the agriculture and the urban sectors, the environment may benefit in two ways. First, the water market induces a shift towards improved water management and efficiency in agriculture, lowering water pollution that is related to irrigation. Second, with the water market, farmers may afford to internalize, externality cost, or even pay higher socially pollution-related cost. However, increased industrial and urban water use may create extensive environmental pollution if necessary measures to limit industrial and municipal untreated sewerage disposal are not introduced.

Disadvantages

Several unique characteristics of water present special challenges in the design of a well-functioning water market. A list of these difficulties include: measuring water, defining water rights when flows are variable, enforcing withdrawal rules, investing in necessary conveyance systems, sale of water-for-cash by poor farmers, and finally, externality and third party effects and environmental degradation: a transfer of water from agriculture to urban use may reduce return flows, which may effect a third party.

Table 1 below summarizes the three mechanisms according to the criteria outlined earlier. It can be seen that there are trade-offs between the various criteria as they relate to the different allocation mechanisms. This fact makes a policy maker's decision as to which mechanism to prefer much more complicated.

Table 1 *- Comparison of Water Resources Allocation Mechanisms with Regard to Various Principles and Criteria.*

Criteria	Marginal Cost Pricing	Public Allocation	Water Markets
Flexibility	❏❏❏	❏	❏❏
Security of property rights	❏	❏❏	❏❏❏
Real opportunity cost	❏❏❏	❏	❏❏
Predictability	❏❏❏	❏❏	❏❏❏
Efficiency	❏❏❏	❏	❏❏❏
Equity	❏	❏❏❏	❏
Political and public acceptability	❏	❏❏	❏❏
Efficacy	❏❏	❏❏❏	❏
Administrative feasibility and sustainability	❏	❏	❏❏
Note: Ranking increasing from ❏ to ❏❏❏			

Source: Authors.

EXPERIENCE FROM VARIOUS COUNTRIES

The allocation mechanisms described above have been applied, with some modifications, to different sectors and locations. In this section we review several interesting cases which provide some lessons to be considered in future implementation of allocation mechanisms.

Marginal Cost Pricing

Given the long list of disadvantages and difficulties of implementing marginal cost pricing, it is not surprising that there are only few good examples of its strict application to water management in reality.

Irrigation water in France

In France, water for irrigation is generally sold on the "binomial tariff" basis. (The binomial tariff system accounts for off-peak and on-peak costs). Jean (1980) describes a system in operation since about 1970. The Société du Canal de Provence et d'aménagement de la Région Provençale supplies water to some 60,000 hectares of farmland. This scheme is thoroughly grounded in the theory of marginal cost pricing, with full recognition of the need to consider and reflect long-run costs if farmers are to make "correct" investment decisions in terms of land, cultivation, crops, irrigation equipment and storage (and, indeed, if the Société itself is to do the same with respect to new water resource works). A peak period is identified lasting for five months from mid-May to mid-September and that plays a central role in the tariff. Tariff design starts from the objective that tariffs should reflect:

- In the peak period, long-run marginal capital costs augmented by operating costs

- In the off-peak period, operating costs only.

For various practical reasons, this objective sometimes has to be compromised. Thus irrigators "correctly" contribute to the capital costs for their distribution network only through an annual charge based upon the peak demand subscribed for by the user. The development costs of the headworks, which in theory should similarly fall within irrigators' demands in peak periods, are in fact lumped in with operating costs in order to establish a single year-round volumetric charge. This results from "considering the nature of the consumption which is distributed in a well-known way between the peak periods and the off-peak periods, [it] simplifies the price scale and enables the use of a single meter reading" (Jean 1980).

For other sectors (e.g., urban, industrial), operating costs constitute the only element in the off-peak volume charge. Off-peak demand thus has no role in determining responsibility for capital cost recovery, precisely as the economic theory of peak demand indicates (see Rees 1984).

However, the French government maintains that the agriculturalists relying on the canal are a beneficiary sector and therefore a state subsidy of 50 percent on all elements of the irrigation tariff is granted. At a stroke, the price signals are clouded and the messages altered. Nevertheless, the concept remains intact (Jean 1980).

Public Water Allocation

Bureau of Reclamation and the American West

In the United States, private groups first invested in major irrigation works in the West in the mid-1800s. Throughout the remainder of the 1800s the U.S. government had a small and somewhat peripheral role in Western irrigation development. By the turn of the century, there was a stronger sentiment for some control of large, western rivers but that the costs of such an endeavour were beyond the means of private irrigation companies (Wahl 1989). This led to the passage of the Reclamation Act in 1902 and the creation of an agency that later became the Bureau of Recreation (BuRec). Initially, the BuRec undertook the building, operation and maintenance of dams, reservoirs and canals to support irrigation expansion in the West. Since 1950 the Bureau of Reclamation, responsible for federal development of irrigation, has irrigated between 21 and 25 percent of total irrigated land in seventeen Western states (Wahl 1989).

The structure of allocation and cost-recovery under the BuRec has evolved over time. Since 1906 the BuRec has had authority to allocate water for irrigation, for nearby towns and cities, and for hydroelectric power. However, the BuRec has no rights to water per se. Rather, it has control and management authority of water distribution and storage systems. Furthermore, the BuRec cannot charge water users more than the capital and O&M costs (Cummings and Nercissiantz 1992).

Public water reclamation for these uses has long been tied to water supply subsidies and the extent of these subsidies has increased over time. These subsidies take two possible forms: interest free repayment schedules, and repayment schedules based upon bureau estimated "ability to pay" (Wahl 1989). As Wahl describes the reclamation subsidy: "What began as a proposal for modest federal assistance in settling the arid West, providing a revolving fund to which costs would be repaid within ten years, evolved into a program that provided major subsidies to irrigation water users--sometimes more than 90 percent of construction costs" (Wahl 1989 p.38).

These programs require host states to provide around 50 percent of necessary funding and also require that the projects demonstrate benefits beyond public benefits. The federal program resulted in more irrigation in the West. That expansion, however, was not without a cost. While many private investments in irrigation in the West failed, the government continued irrigation subsidies to water users and averted farm failures by extending repayment periods, deferring repayment, and sometimes forgiving repayment altogether (Wahl 1989).

At a national level, "...extensive water subsidies have led to inefficient use of land and water resources as well as capital, labor and materials." (Wahl 1989 p.45). The costs of many subsidy-supported projects sites exceeded benefits. "Consequently, dams have been placed where rivers, in the absence of the irrigation subsidy, would have been left in their natural state. Furthermore, low-cost water has provided little incentive for careful use of the resource. This means that water has been diverted to uses other than those that would produce the greatest economic benefits and has, for the most part, continued to be used for the original purposes." (Wahl 1989).

The PASTEN Mechanism in Indonesia

The PASTEN system, which is administered by the Water Resources Division (WRD) of the Ministry of Public Works in Indonesia, is a process of determining fixed proportions of water to allocate it across tertiary-level irrigation units (Howe 1990).

The PASTEN allocation mechanism, described in Box 2, takes into account different fields and canals losses, it takes into account the different cropping patterns in a simple way that can be adjusted as crop stages change, and it provides a set of computable guidelines for the water management team who must allocate the water by controlling flow rates at various gates. No consideration is given, however, to economic values of different crops, differing productivity of individual tertiary units, and to opportunity costs of water not used in other projects on the river basin. The PASTEN mechanism is incompatible with the efficiency criteria because it sets proportions of water to be applied to each crop based upon the maximum physical yield possible.

Box 2: Principles of the PASTEN Allocation Mechanism.

The basic design consists of biweekly calculations of the "full water requirement" of each tertiary unit given the crops and their growth rates in each unit. To this amount is added the amount of water that can be expected to be lost before application (terrain, soil type, canal loss). The sum is an estimated "full diversion requirement" (DR) for each unit. The full diversion requirement is compared to the known total water available in the system to estimate a "PASTEN Index," or K value, which is actually a ratio of available water to DR. When available water resources at least meet DR, the K value is equal to 1 or more. A water shortage means that K is less than 1.

The allocation of water then is done in fixed proportions across all irrigation units. Proportions allocated are based on the ideal water applications given no scarcity, and the delivery and application losses of each unit (Howe 1990).

Water Markets

Water markets are relatively new in many regions, although in Spain they have functioned for several centuries (Reidinger 1994). One can find variations that include surface water markets, groundwater markets, water auctions, and water banks. In this section we review two case studies from Chile and California that feature variations of the of surface water trade principles.

Water Markets in Chile

Chile's National Water Code of 1981 established a system of water rights that are transferable and independent of land use and ownership. Water rights are defined as permanent (from unexhausted sources) or contingent (from surplus water), and as consumptive or non-consumptive. Rights can be obtained by petition to the government or they can be established by right based on historical use; they can also, of course, be purchased from the owner. In practice, the second of these methods has been used the most to establish water rights, because the government's 1966 expropriation of all water rights has necessitated establishment or re-establishment of those rights since the National Water Code was passed.

The most frequent transaction in Chile's water markets is the "renting" of water between neighbouring farmers with different water requirements

(Gazmuri 1994). This can also be termed a "spot market" in which the owner sells a portion of his or her water, usually over a brief period (perhaps even hours), sometimes without fulfilling formal, legal requirements. Although the volume of sales may not be metered, the buyer and seller have good information on the amount exchanged. Compensation may be in kind or in some other form of monetary or non-monetary benefit.

The formal buying and selling of water-use rights in Chile requires legal sanction and registration. Although the law defines water use rights as a volume of flow per unit of time (24 liters/sec), in practice rights are a share of stream flows, since variability renders the volumetric/time specification impractical. Use rights are required for groundwater exploitation; these rights prohibit the user from other withdrawals within the area specified in the right. There is a system in place for challenging the granting of water rights and for resolving disputes related to them.

Prices for water rights are left to the buyers and sellers. In a draft study covering over 700 shares of water in four river valleys in Chile, Hearne and Easter (1995) found that for both intra- and inter-sectorial transactions, "market transfer of water-use rights does produce substantial economic gains-from-trade," in the two valleys were transactions were numerous. In the Elqui Valley, for example, net gains from trade were calculated to be in the range of US\$5.99 and US\$1642.00, with an average of US\$826.00 per share of water traded, depending on the type of trading sectors. In the Limarí valley the net gains-from-trade were calculated to be in the range of US\$1.65 and US\$2.85 with an average of US\$2.40 per cubic meter. In the Limarí Valley 1 share equals, on the average, 4880 m^3/year, so that the average gains from trade in the Limarí Valley are US\$11,700 per m^3. There were some instances of high financial but low economic gains to society from some inter-sectorial trading.

Drought Water (Market) Bank in California

A water bank is an institution that offers to buy and sell water under some set of rules regarding prices and quantities, in a given service area. Water banks can mark up water prices to cover transaction costs and can also use it to compensate the area of origin.

There are several examples of efficient and equitable transfer of water by water banks (Howe and Goodman 1995). We will present here the *California drought water bank of 1991-92.*

After five years of continuous drought, an emergency drought water bank (DWB) was set in California, following appropriate legislation (to allow for transfer of water rights). The aim of the DWB was to enable transfer of water from agriculture in northern California to urban, municipal, and agricultural sectors in southern California. The principles of the DWB were:

- Voluntary transfers
- Protection of fish and wildlife
- Protection of ground water basins
- Efficient use of water in receiving areas
- Protection of present water right holders.

In 1991, the purchase price by the DWB was set to \$125/acre-foot[(1)] and the sale price by the DWB was set to \$175/acre-foot. As a result, more than 300 transactions were recorded. The DWB bought 820,000 acre-feet, and sold was 389,952 acre-feet, mainly to urban and industrial users (32%), and to agricultural users (16%). The difference (quantity not sold) was used for the environment (20% of the total) and for recharge (32% of the total); part was also lost in the system. The value of water purchased by DWB was \$102,500,000 and the sale value was \$68,241,600. Direct and indirect effects of the DWB in 1991 were analyzed by Coppock and Kreith (1992) and Howitt et al. (1992) and include increased income in receiving areas. Negative indirect effects were noted on soils, wetlands, and third party effects in the form of unemployment in the selling areas.

PROSPECTS FOR THE MEDITERRANEAN AND MAGHREB COUNTRIES

Water was always been a central concern in many Mediterranean countries. Some of the countries in the region experience presently very severe water scarcity, however, all the countries face a trend of declining water availability in the future, as can be seen from Table 2.

(1) 1 acre foot equales 1235 m^3

Table 2 *- Present and Future Annual Fresh Water Availability in some Mediterranean Countries.*

		1955		1990		2025 (UN medium Projection)		2050 (UN medium projection)	
Country	Total Annual renewable fresh water (km^3)	Population (10^6)	Per capita water availability (m^3)	Population (10^6)	Per capita water availability (m^3)	Population (10^6)	Per capita water availability (m^3)	Population (10^6)	Per capita water availability (m^3)
Algeria	158.0	9.7	1770	24.9	690	45.4	378	55.6	309
Bulgaria	205.0	7.4	27337	8.9	22800	7.7	26390	7.0	28910
Cyprus	0.9	.5	1698	.7	1282	.9	971	1.1	895
Egypt	58.9	24.7	2385	56.3	1046	97.3	605	117.4	502
France	185	43.4	4260	56.7	3262	61.2	3021	60.4	3059
Greece	59.0	7.9	7406	10.2	5763	9.8	5979	8.6	6868
Israel	2.1	1.7	1230	4.6	461	7.8	275	8.9	241
Jordan	1.3	1.4	905	4.2	308	12.0	109	16.8	78
Lebanon	5.0	1.6	3087	2.5	1949	4.4	1126	5.1	960
Libya	4.6	1.1	4103	4.5	1017	12.9	359	19.1	242
Morocco	28.0	10.1	2764	24.3	1151	40.6	689	47.8	585
Portugal	66.0	8.6	7666	9.8	6688	9.6	6815	9.1	7221
Spain	111.0	29.2	3802	39.2	2826	37.6	2954	31.7	3494
Tunisia	4.3	3.8	1130	8.1	540	13.2	328	15.6	279
Turkey	203.0	232.8	8508	56.1	3619	90.9	2232	106.2	1910

Source: Population Action International (1995)

To better demonstrate the harsh situation some countries in the basin face, refer to Figures 1 and 2 that depict trends in population growth (Figure 1) and in per capita water availability for the next 60 years.

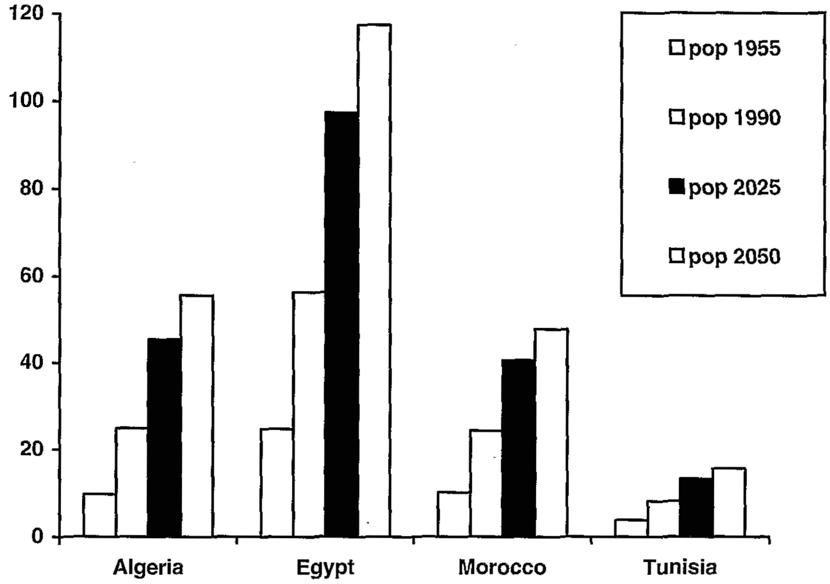

***Fig. 1**- Population growth trends in several water-scarce Mediterranean countries.*

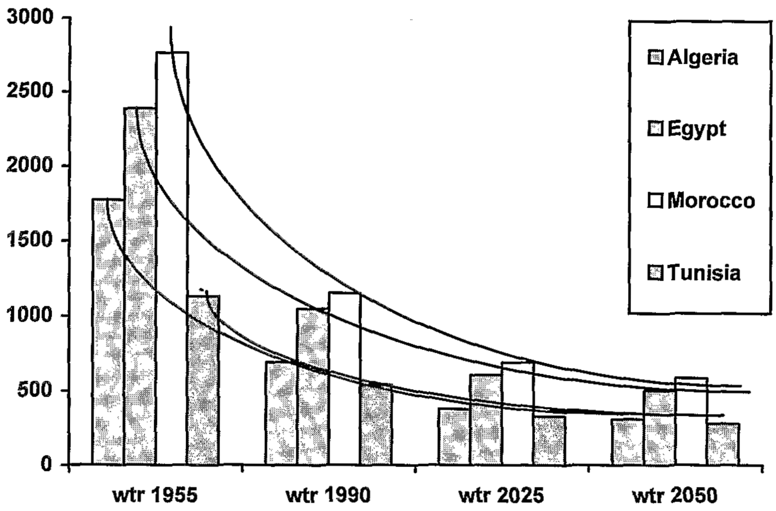

***Fig. 2** - Projections per capita availability of water resources in several water-scarce Mediterranean countries*

The information in the figures calls for serious consideration of action, in several water-scarce countries in the basin. The following section presents two country case studies. Both countries face water scarcity. Jordan is already facing severe water shortages, and water is becoming a scarce resource in Morocco. The governments of both countries are committed to making necessary changes in order to improve management of their water resources.

Jordan: A Modified Price System to Motivate Conservation

Jordan's water resources are far short of meeting existing needs. While the total amount of water sources in Jordan is 553 million m^3 per year, the 1990 use was 874 million m^3. The difference of 321 million m^3 is an overdraft from groundwater aquifers. Almost all Jordan's water resources have been used and the marginal cost of developing new sources (e.g., desalinization) is very high. A potential solution may be in managing the resource as an economic good.

Although agriculture's share in the GDP is only 7%, its share in available water use is 75%. Most of the agricultural activity in Jordan is concentrated in the Jordan Valley while the majority of the population is in the urban centers in upland areas. So, in addition to competition over scarce water resources there is an additional conveyance cost associated with transferring the water to urban uses. Crop water requirements vary substantially between regions due to soil and climatic conditions. Upland irrigation is based mainly on ground water extraction. Private wells are not monitored. The cost of pumped water in 1993 is estimated at 50 fils/m^3 (1000 fils = 1 Jordanian Dinar. In 1993 1 Jordanian Dinar = $US1.5, and in 1986 1 Jordanian Dinar = $US2.85). In the Jordan Valley, water is provided through pipes to more than three quarters of the irrigated land. Volumetric pricing is used, but water is greatly underpriced. For example, in the East Ghor canal (Jordan Valley Irrigation Project) farmers were charged 3 fils/m^3 for the first 1.5 meters of irrigation depth and 6 fils/m^3 for any additional amount. O&M costs alone are estimated at 20 to 30 fils/m^3 (Arar 1987). In 1993, all irrigation water in the Jordan Valley were priced at 6 fils per m^3 irrespective of the volume used (Hayward and Kumar 1994).

Although most of the water supply to agriculture is piped, and easy to monitor, the existing price method does not take advantage of it. Irrigation water in the upland area is neither monitored nor priced. In the Jordan Valley, the volume supplied to individual users is measured but the price does not influence efficient use of water. Allocations are based on the crop grown and water availability. This "social planning" mechanism prefers equity over efficiency of water use, and leads to inefficiency of resource allocation, improper management, and selection of low profit crops, most of which can not cover the real cost of water. Profitable crops such as citrus (10,000 m^3/ha), bananas (20,000 m^3/ha), and grapes (8,000-11,000 m^3/ha) are water-intensive. Since water is scarce in Jordan, price signals may not be sufficient to allocate the water, and additional guidance from the government, in the form of preferred cropping patterns, need to be provided. This may create an additional food security policy dilemma.

On the other hand, water for municipal and industrial uses, which is also metered, is priced on the basis of a block tariffs imposed every three months. The water component in the pricing scheme (there is also a sewerage charge) vary by location, which reflects the marginal cost of water supply. Water charges in these sectors vary between 60 to 600 fils/m3 (in 1993), depending on the quantity and the location.

A water price system for irrigation that takes into account the social consequences of the resource scarcity is evaluated by the Government of Jordan (Hayward and Kumar 1994). The implementation of the new price system will evolve over a transitional period in which block water prices will be increased gradually, taking into account seasons, regions, and crops. The final average rate will be close or equal to the 50 fils/m3 bench mark targeted by the authorities.

The modified price system intends to motivate farmers to conserve water either by improved management, selection of water efficient crops, or investment in improved irrigation technologies. Some water may be released from the agricultural region of the Jordan Valley and sent to urban areas around Amman. In order to take advantage of both the conservation and the transfer of water that result from more appropriate price signals, the government considers necessary institutional and legal frameworks, financial help, and invest in conveyance systems.

Morocco: Calculations of the Mobilization Costs of Water

For the past thirty years, the Government of Morocco, in order to meet objectives of increasing agricultural incomes and pursuing self-sufficiency and export growth, has emphasized the need to develop water resources quickly and efficiently. The water development strategy calls for construction of large- and medium-scale dams to serve regional water demands as well as to transfer water between basins. Cost recovery is limited to the distribution rather than the mobilization of water resources; water is supplied free of charge at the head of the irrigation perimeters or at the point at which it enters the primary distribution point for potable water supply. To consider the long-run marginal cost of water and alternatives for water supply on the basis of existing data, a few simple techniques were applied.

In surplus water basins, the long-run marginal cost may be deduced by assessing the costs of new dams and distribution systems after accounting for externality or third-party effects. When these costs exceed the opportunity cost of water in agriculture, for example, then in principle it would be preferable to reallocate water from agriculture to municipal and industrial users. In deficit basins, the long-run marginal cost may be deduced from the cost of transfers from other basins, or, by taking these costs and including a valuation of the externalities and third-party effects (including effects on agriculture in the originating basin). If these costs exceed the opportunity cost in agriculture in the receiving basin, or the costs of desalination and distribution, then reduction in water use in agriculture and/or desalination is preferable to the transfer.

A preliminary assessment of the long run marginal cost of water in Morocco was made by estimating construction costs for the 51 dams scheduled for completion between 1993 and 2025, assuming a constant inflation rate of 7% per year from 1993. Total mobilized volume throughout the life span of each dam was then calculated by multiplying yearly volume flow by an estimated life span of 50 years. Dividing construction costs by total mobilized flow yields a ratio of construction costs in Moroccan Dirham (DH) to cubic meters of water flow, which can be used to compare the relative cost per cubic meter of water mobilized by different dams. A weighted average would give an indication of the mobilization costs in a river basin. These indicators provide orders of magnitude of the long-run marginal cost of water.

For example, the three dams located in the Mediterranean region of Tetouan, which cost more than 7 DH/m^3 in construction cost alone, will provide domestic and industrial water exclusively. These dams mobilize water at a cost that is lower than the costs of a transfer from outside the basin or from desalination. An examination of the economic returns to agriculture in this basin highlights the fact that the return to water use seldom exceeds 0.42 DH/m^3. This suggests that the opportunity cost of new supplies greatly exceeds the economic cost of reallocation of water from agriculture to the other sectors.

Failure to include this reallocation of water from the agricultural sector suggests that the long-run marginal cost of water in the Tetouan may be much higher than would be the case if the opportunity cost of alternative uses in included in the analysis. Analysis of the opportunity cost, as noted above, must include consideration of the externalities. In irrigation, these include employment creation and poverty alleviation, which are accorded a high social priority. These benefits, however, need to be evaluated in light of the costs of subsidies to the irrigation system.

DISCUSSION

In many countries, water is an increasingly scarce resource that requires careful economic and environmental management. Competition over scarce water resources by many economic sectors calls for careful allocation of the resource so that its economic value is realized and social benefits are maximized.

Treating water as an economic good, with the goal of establishing efficiency in its allocation and use, can help to achieve social objectives. The purpose of this paper is to present basic considerations in the choice of water allocation mechanisms and offer a few examples of how these mechanisms are (or can be) included in water allocation decisions in several countries.

In practice, most countries have some combination of water allocation mechanisms. Each allocation mechanism has advantages and disadvantages. Efficiency is an important goal, but the allocation mechanisms that are considered efficient, are often hard to implement, and require supporting institutions, in addition to expensive monitoring and enforcement systems. Therefore, top-level commitment to water allocation that pursues economic efficiency is needed. Moreover, if the principles discussed in this paper are to be used, countries should make the commitment to developing and supporting the institutions and individuals that will be putting these principles into action.

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