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WATER INSTITUTIONS AND ECONOMIC INCENTIVES TO AMELIORATE MARKET AND GOVERNMENT FAILURES

by

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I. **Introduction**

In recent years, water management issues have come to the forefront of policy discussions in many countries, as well as in international development agencies. The reasons for the increased interest are apparent when one observes that twenty-one countries around the world have renewable water resources of less than 1,000 cubic meters per-capita, a level commonly taken to indicate a severe water stress. Another eighteen countries are within the range of 1,000-2,000 cubic meters per capita, which is associated with periodical stress. In many other countries the problems are concentrated in specific regions or at certain times of the year. With world population expected to grow by some 55 percent over the next generation (mostly in developing countries), problems are likely to become even more acute. The demands for food (and hence for irrigated agriculture) will increase, as will the demand for water for domestic consumption and industry. The growth in income, and the consequent changes in consumption patterns in ways which further increase the demand for water is another likely development. A reexamination of the ways in which water is allocated and managed is thus warranted, and indeed, has been the topic of a burgeoning literature (Chang and Griffin, 1992; Spulber and Sabbaghi, 1994; and Shah, 1993).

Because water is critical to human survival, and because reliance on market forces alone would not bring about socially optimal solutions, public authorities in most countries have assumed vast responsibilities for the overall management of water resources. Indeed, both central

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control and community control have long histories. State development of irrigation systems was important in ancient Mesopotamia, Egypt, and the Roman Empire (Said, 1981). Communal irrigation systems have existed for generations in countries such as Thailand, India, Sri Lanka, Bali, Indonesia, the Philippines, and Nepal (Easter, 1986). In the Philippines, the "zangjera" system of cooperative irrigation management dates back to the 1600's (Lewis, 1980). Water user organizations have existed in Tunisia for most of the 20th century, with the French Colonial government establishing their legal basis in 1913.

In pre-Columbian Latin America, the native empires maintained central control over complex irrigation systems. Many of these physical structures survived colonial rule but the Spanish imposed a system based on individual water rights that they inherited from their Moorish tradition (Lee, 1990).

The performance record of publicly-owned and managed water services system is, however, unsatisfactory and declining in many developing countries. Even in the industrialized economies such systems often perform at a lesser efficiency than that of the private sector. At the macro level, the way water resources are managed results in major misallocations as well as quality deterioration. It has become apparent in many cases that current practices and policies are not sustainable, and that reforms are needed. The present paper focuses on some of these reforms. It starts by reviewing and analyzing the sources of the market failures as well as government failures in water resources management. Recognizing the inevitability and desirability of some form of public action in many circumstances, it seeks to identify forms of interventions that utilize, to the extent possible, individual or private incentives by providing the institutional and legal framework in which these incentives can best complement the interventions. Examples from various countries are provided to illustrate the feasibility and merits of the proposed reforms.

II. Market Failures in Water Management

Water has a number of characteristics affecting its "production"[1] and delivery to users which create market failures. These market failures, as well as the political economy considerations, and the often misguided notions on the best ways to contravene market failures, have induced governments to intervene heavily in both the production and delivery of water services. In many cases the intervention entailed complete government control (whether at the local-municipal or provincial-national level) of segments of the water sector, such as irrigation or domestic water supply. These interventions have frequently resulted in poor quality service.

Fresh water is a renewable natural resource moving through an intricate hydrological cycle of rainfall, absorption, runoff, and evapotranspiration. This makes water activities highly interdependent, resulting in numerous externalities (mostly negative) from various uses of surface and groundwater. For example, pumping groundwater from an aquifer by one user reduces the water table and increases the pumping costs for other users. Pollution of water by an industrial user reduces the quality of water for other users. These are classic examples of negative externalities, but there are other, more intricate ones. Many uses of water are not fully consumptive, because part of the water being utilized is recharged to the basin system. But the precise relationship between the use and the return flow cannot be traced to any single user, and the decision by one user regarding water withdrawal does not consider the implications to other water users in the basin. These externalities imply that private market forces would not lead to an optimal allocation and use of water.

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[1] We use the term "production" to describe the various steps needed to make water suitable for specific uses, e.g., storage through dams, pumping from underground aquifers, desalinization, or treatment of waste water to facilitate reuse.

Many of the investments related to water production are very large, entailing a large fixed cost, while the average cost per unit of water delivered is declining (e.g. dams). Similarly, the supply of water (whether for agricultural or non-agricultural uses) often requires a dedicated delivery system (e.g., piped water, or a canal system) such that no other goods can be delivered through the system[2]. Investments in such delivery systems entail a heavy fixed cost which is irrecoverable, because they cannot be converted to other uses, e.g., a high level of asset specificity which makes competition difficult. Both production and delivery systems often exhibit economies-of-scale, whether at a national or local level, giving rise to natural monopolies.

Natural monopolies, such as large dams, main canal networks, and large urban sewerage and water supply systems, have a tendency to charge more for their services and produce less than what would be observed under competitive conditions. Furthermore, because entry costs can be extremely high, the threat of entry of would-be-competitors, i.e., the level of contestability of the service, can be low and the incentives for innovation and dynamic efficiency are diminished.

The contestability of different water production and service delivery systems varies across the different activities and is likely to differ between production and delivery of a specific service. It is easier for firms to enter and exit activities when they do not have to make large asset specific capital investments. Therefore, in activities where capital costs are relatively modest, the market power of any existing monopoly can be challenged, provided that the legal framework facilitates such challenges. A separation between the production aspects of some water services, where contestability may be low, and the service delivery itself, where contestability may be much higher, can help reduce monopoly power in service delivery. For example, the construction of a large

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[2] Some main canals can be used for navigation, and some reservoirs can be used for recreation, but most secondary and tertiary open distribution systems are dedicated.

reservoir and the laying of a piped distribution network for an urban water supply system may exhibit low contestability, but the day-to-day management of water delivery and operational maintenance, if defined as a distinct service, is contestable and thus amenable to efficient decisions-making due to potential competition.

A complication in the case of the delivery of water services is the geographical span of conveyance systems. These systems may require the moving of water from sources (rivers, reservoirs) over large distances to the locations of use. In many cases, the areas over which the conveyance infrastructure (canals, pipes) is to be constructed are private properties. The piecemeal negotiation of the acquisition of the necessary areas is theoretically possible but entails a high transaction cost as well as potential delays. Such costs are much lower when the negotiator is a government empowered by "eminent domain" privileges to override private property rights.

A key factor in many governments' rationalization of direct control over water services' production and delivery is the perceived prevalence of public good characteristics. In reality, water services vary considerably in their characteristics and a more detailed analysis of their private and public good aspects is required. Thus it is important to examine the extent of rivalry (or subtractability) and excludability (i.e. the ability to condition service delivery on payment) in water systems. The common conceptual approach is based on a two-by-two classification, whereby goods and services are either (a) public goods (low rivalry and low excludability), (b) private goods (high rivalry and high excludability), (c) toll goods (low rivalry and high excludability), or (d) open access/common property resources (high rivalry, low excludability). Public goods and toll goods would typically be under-provided (or not provided at all) by market entities, while open access resources tend to be over-used under free market regimes. In many cases the distinctions are not as

sharp as the classification implies, but it is quite accepted among economists that infrastructure for flood control and large multi-purpose dams are local public goods. Similarly, water treatment plants are commonly viewed as toll goods, because connections establish easy excludability, while rivalry is quite low until the full capacity of the plant is reached. Groundwater aquifers are, in most cases, open access resources, as are many gravity flow field-to-field tertiary irrigation systems (Table 1).

In all cases except pure private goods, a certain degree of government involvement may be required to bring about an optimal allocation of resources. This can range from full public ownership and control in the case of pure public goods or some open access resources, through public financing and partial control in the case of toll goods, to regulation and granting of communal property rights.

The extent of excludability is determined by the transaction cost of enforcing exclusion. Because of the importance of excludability in establishing market entities' incentives to invest in infrastructure and operate water facilities, the examination of these transaction costs, and of the possibility of reducing them, is of importance. The costs are often a function of the technology available, especially the specificity of the capital investment associated with the technology. Thus, until the invention of cast-iron pipes and steam-driven pumps in the mid-nineteenth century, the cost of excluding individuals from access to water sources (rivers, lakes) was prohibitive and commercial water supply for domestic uses was limited to a very narrow segment of the clientele (World Development Report 1994). The ability to monitor volumes of use through individual water meters allows further efficiency gains. If the volume of utilization cannot be determined, price signals cannot affect the marginal levels of use, with a likely efficiency loss. In the case of gravity-

Table 1. Public and Private Good Characteristics, Market Power, and Externalities in Water Systems

	Rivalry	Exclud-ability	Contest-ability	Externalities
I. Water Supply				
A. Piped				
1. Trunk System (dam, well) [1/]	H	H	L	PH, GD
2. Distribution System	L	M	L	PH
3. Terminal Equipment				
a. Common (i.e. hand pump)	M	L	H	PH
b. Individual (i.e. home faucet)	M	H	H	PH
B. Village wells	M	L	H	PH
C. Vending (tanker trunks etc.)	H	H	H	PH
II. Irrigation				
A. Production				
1. Trunk System (dam, main canal)[2/]	M	M	L	WL, ND
2. Small dams and reservoirs[2/]	M	M	M	
3. Run of the River Systems[2/]	M	M	M	
4. Deep Tubewells[1/]	H	H	M	GD, WL
5. Shallow tubewells[1/]	H	H	H	GD, WL
B. Distribution System[2/]	M	M	M	WL, ND
C. Terminal system (on farm) gravity				
1. Field to field irrigation	H	L	H	WL, ND
2. Field channels	H	H	H	WL, ND

PH = Public health
WL = Water logging and salinity
ND = Introduction of new diseases
GD = Groundwater depletion
L = Low, M = Medium, H = High

[1/] The degree of rivalry associated with a given well depends on the nature of the aquifer and the capacity of the well relative to demand. High water resource scarcity is assumed. Excludability refers to the well and not the aquifer.

[2/] The degree of rivalry depends on the scarcity of water and the canal capacity.

based irrigation systems, the volume of flows can be established by fixed flow dividers. However, changing the fixed dividers is costly and thus adjustment of the flow to accommodate transactions are usually expensive. A more advanced technology allowing adjustable dividers is available but it entails a higher initial fixed cost.

The cost of enforcement can often be reduced when community action substitutes for expensive technology or for costly exclusion by a centralized water service entity. The reason is that local organizations have the capacity to monitor use at low cost as well as apply peer pressure (using the intricate web of social ties within a small community) to enforce agreed upon levels of use or payment. The low costs are due to the fact that such monitoring and enforcement can be done by members of the community on part-time basis or while performing other productive activities (e.g., tending fields).

The cost of public action is also a relevant concept in analyzing the consequences of another attribute of water. By its very nature, water transactions among different users seeking to adjust their initial endowments often require the collaboration of other users. For example, when a farmer along a canal wishes to sell his water allocation to another farmer at a different outlet on the canal, all farmers in between the outlets must agree to coordinate their water use. If a large scale user (e.g. a municipality) wishes to purchase water from many small scale holders of rights, the negotiations are much more efficient when these holders are organized and the transaction can be concluded in a bargaining process between only two parties. If the cost of organization is high (e.g. due to lack of tradition of collective action or due to significant heterogeneity of small users), transactions that would have been otherwise beneficial to society (and to each agent) are foregone. In some cases, governments can reduce organization costs by establishing the legal framework which provides

legitimacy and regulatory oversight increasing the trust of potential members of the organization. In other cases, the benefits of organization are sufficiently large compared to the cost, so that spontaneous organizations emerge even in the absence of a formal legal framework. This is often true in the case of open access water resources, where all members of a community have an incentive to exclude non-members who are easily recognizable. Even the Bible cites stories on how groups of herders within a certain territory will prevent perceived "strangers" from using wells within the communal domain.

Some water services cater to social objectives that have wide political acceptance and are thus considered "merit goods," i.e., their consumption has benefit to society beyond that which accrues to the individuals consuming them. The access to a certain minimum level of water for human consumption is generally perceived to be such a good, hence subsidies to enhance access to water supplies are common in many countries. Merit goods generally have very low price elasticities of demand at low (basic) levels of use. Because some water services, such as drinking water, are merit goods, they receive political attention, and private entities providing these services can be subjected to political intervention if prices are perceived as too high. Furthermore, since water used in other activities (such as irrigation) could potentially be used for human consumption, entities dealing with these other services could also be affected by politically motivated interference. The political sensitivity of water as a merit good, combined with the large size (relative to the size of capital markets) and extremely long time horizons of many water projects, reduce the incentives for private investments in the water sector, and lead to a situation where market forces would not, in many cases, generate adequate levels of investment, *ceteris paribus.*

The variability of natural water supplies in some regions, due to erratic rainfall patterns, causing periodic droughts creates an additional situation where the distribution of water among users by market forces alone could be widely perceived as inequitable and unacceptable. Thus domestic uses are, in many cases, given preference or first priority during droughts or low flow periods. Indeed, even in areas where water allocation is done largely through the pricing mechanism (e.g., urban areas), governments intervene, at the time of droughts, by imposing rationing or other quantitative restrictions, essentially due to the perception of water for domestic use as a merit good.

III. Government Failures

Given these characteristics and perceptions of water, governments have created agencies (or public utilities) that financed and maintained public ownership of infrastructure, and formulated various regulations pertaining to the allocation, use, and disposal of water. However, this approach to contravene the undesirable effects of market failures has not been free of problems. These problems have been particularly acute in developing countries, but many developed countries have experienced problems of the same nature. The problems encountered include:

(i) Misallocated project investments: water production or distribution infrastructure has often been premature (i.e., investments could have been deferred while demand management is exercised or where maintenance could be improved) and excessive, resulting in unusable excess capacity. Demands for service of varying quality and affordability are unmet even when users are willing and able to pay. (Low income communities are not offered an option of a lower standard/lower cost water supply and sanitation system which they can afford.) Investments in specific subsectors are based on a narrow analysis of water demands and productivity within the specific subsector (e.g., irrigation) and may neglect the implications

for other water using sectors.

(ii) Overextended Government Agencies: The heavy reliance on government agencies to develop, operate, and maintain water systems has often stretched too thin the government's already limited implementation capacity. Moreover, in most cases users have not been consulted or otherwise involved in planning and managing the water resources. The result has been a vicious cycle of unreliable projects that produce services that do not meet consumers' requirements and for which they are unwilling to pay. The absence of financial discipline and accountability for performance — along with political interference in decisions about allocations and pricing — are reflected in a litany of problems: inefficient operations, inadequate maintenance, financial losses, and unreliable service delivery.

(iii) Inadequate Service Delivery to the Poor: Nearly 1 billion people in the developing world lack access to potable water, particularly the rural poor, and 1.7 billion must contend with inadequate sanitation facilities. Thus, while the upper and middle classes often receive subsidized services, inefficient public water operations have little funding left for extending services to the poor. Large numbers of poor people in urban areas depend on water vendors, paying at least ten times what a middle-class person pays for a gallon of water (World Bank, 1994).

(iv) Neglect of water quality and environmental concerns: While it could have been expected that, with the dominance of public sector control over water resources, environmental and health externalities would be minimized, this has not been the case in many developing countries. Water supplies are often of poor quality and unsafe for human consumption. Using polluted waters for human consumption is the principal cause of many health

problems such as diarrheal diseases, which kill more than 3 million people each year--mostly children--and render sick a billion more. In addition to human suffering, water pollution causes devastating economic and environmental damage.

In part, the problems observed can be traced to domestic political factors. For example, a policy of pricing of water by public entities well below its economic value (a prevalent phenomenon throughout the world) is done for political expediency, as it is much more popular to expand water supply through infrastructure development. The practice is very common with respect to irrigation water, leading to gross resource misallocations, the adoption of water-intensive crops in water-scarce areas, and the maintenance of an over-sized irrigation and agricultural sector. A recent review by the World Bank indicated that in a large sample of urban water-supply systems, the charges to consumers cover on average only 35% of the cost of supply. Charges in most irrigation systems are even lower (World Bank, 1993).

Political interference and rent seeking by government officials are also responsible for over staffing of public water service organizations, senior appointments of unsuitable personnel, and preferential treatment of certain types of users even when net economic returns would dictate different areas of concentration. The imposition of non-economic decision rules contributes to the impairment of financial viability, leading in turn to the cycle of poor services and nonpayment of fees. But financial inviability is also an endogenous outcome of the flawed incentives in publicly-managed institutions, as demonstrated convincingly by Zeckhauser and Horn (1989) and De Alessi (1984). Publicly-owned service entities are characterized by extremely diffused and non-transferable ownership, where the owners (the public) are at a disadvantage in blocking the pressures of special interest groups for preferential treatment. Spulber and Sabbaghi (1994) point out that "the diffused

and non-transferable public ownership reduces the scope of incentives for those who control the enterprise to act in ways that promote public-interest objectives" (p. 200). The pressures of competition, and the incentives for efficiency which they would engender, are absent under the typical public ownership set-up. The situation is very different for private enterprises, where managers are much more accountable to the shareholders even when ownership is diffused, and face credible threats of dismissal if their performance is unsatisfactory to the shareholders. Managers of public enterprises have less incentives to seek profit-maximizing rate structures. For example, public enterprises were found to use less peak-load pricing than private enterprises (De Alessi, 1984). Furthermore, the lack of incentives for economic efficiency is not compensated by accountability in achieving non-economic objectives of society (e.g., by achieving equity objectives).

IV. Correcting these Failures

Given these negative experiences with past government interventions in water management and the deficiencies of unfettered market solutions, policy makers have found it difficult to devise effective management strategies for water resources. The problem is to improve water management by devising a mix of government activities and market based incentives that are consistent with a country's policies and capabilities. One key aspect of such a strategy is to establish an appropriate legal, institutional, and economic policy framework. This framework should provide regulatory oversight to protect service quality, safety, and the environment, as well as ensure access to domestic water supplies at reasonable prices.

Once such a framework is in place, it is much easier to introduce private incentive based solutions to water management problems. Since it has been difficult for countries to establish such policy frameworks, it has also been difficult to use private incentives based approaches in providing

water. Yet there is a growing list of success stories where private incentives have been used to improve water management.

Unbundling Activities

A better understanding of the strengths and weaknesses of governments and markets has helped a number of countries devise more effective strategies for providing water services. The vertical and horizontal unbundling or separation of water resource activities has helped make private incentive based mechanisms more effective, especially when economies-of-scale are not important in the unbundled segments (World Bank, 1994). Examples of horizontal bundling of water services are fairly common, since many cities or villages have constructed and operated their own water systems. Vertical bundling of services involves one entity operating the complete water system from the reservoir and water treatment facilities to the household. These activities can be unbundled and private entities can contract to provide individual services such as metering and fee collection, canal and pipe maintenance, and managing the treatment plant. The experience with the unbundling of activities and the use of private sector incentives is growing and provides us with new insights into how countries can improve their water resource management.

To facilitate the discussion of these experiences, alternative incentive mechanisms are grouped under three headings; (1) accountability and privatization, (2) water markets, and (3) collective action. Under accountability and privatization, the emphasis is on contracting for services between public entities and private firms and on the expanded private use of groundwater for irrigation. The second section considers the growing number of water markets that have been discovered or implemented in the last decade. Finally, the section on collective action focuses on

water user associations (WUA)[3] both for irrigation and domestic water supply and their incentives for providing improved service.

Accountability and Privatization

One of the more successful approaches to establishing accountability and improving the delivery of water to consumers, has been to establish financial autonomous water utilities and/or contract with private firms to manage various water delivery functions. The latter ranges all the way from competitive contracts for collecting user fees, to agreements for operating and maintaining a city's water system over a ten year period. To encourage competition, the long term agreements can be subject to rebidding after five years if the firm has not fulfilled certain efficiency and performance criteria.

The basic idea is to introduce market forces and commercial principles to improve the efficiency and accountability in the delivery of water services. In countries where either the private sector is too weak to perform the needed services, or the government wants to maintain direct control over the water facilities, accountability can be introduced by making the public utilities financially autonomous.

There are a number of examples of public enterprises that have been reasonably effective in providing water services for domestic uses in Korea, Singapore, Togo, and Botswana. The success in Botswana over twenty years shows that it is possible for developing countries to provide high quality twenty-four hour service to most of a city's service area. The overall water losses of twenty-five percent in Botswana are good even compared to many developed countries. However, recently

[3] Water User Associations are broadly defined to include all organized groups of water users that are to some degree involved in the management of water.

there has been a lag in the adjustment of water rates in Botswana and the risk of future water shortages is growing (World Bank, 1994). This points out the difficulties involved in keeping public enterprises autonomous from political pressure.

In Korea, the use of performance contracts appear to provide the accountability necessary to improve performance. For Botswana, the contracting for management has been an effective tool, including the contracting with ex-patriots. Thus there are different contracting mechanisms which can be used to establish accountability.

The use of service contracts has also helped public water agencies introduce accountability and improve water deliveries. Important in these contracts are clear rules and responsibilities for the government as well as the firm contracting to do the service. One of the best examples of contracting out for services has been the public water company in Santiago Chile. It has used private contracts for meter reading, pipe maintenance, billing, and vehicle leasing. In fact, it has even encouraged its own employees to establish private companies to contract to provide these services. Similarly, service contracts for maintenance of irrigation systems and the collection of user fees have been utilized in a number of developing countries such as the Philippines.

Management or service contracts with private firms are limited in duration and are normally conditional on performance. Contestability for contracts needs to be established so that competition for the contracts will induce firms to be more efficient in meeting the performance criteria. Contestability and competition are normal features of the private sector but competition for the right to provide the water service can also exist between public and private enterprises or between public entities.

When public entities are willing to give up direct control over their infrastructure, leases or long-term contracts can be used. For leases, the contractor bears most of the commercial risk but not the financial risk for making large capital investments. In long-term contracts, the contractor must also make capital investments and assume some of the financial risk. Such leases and long-term contractual arrangements have been important in improving the water supply systems in Guinea and Côte d'Ivoire. In the Côte d'Ivoire, a private company under a long-term contract started operating Abidjan's water system thirty years ago and now manages 300 piped water supply systems across the country. For the past ten years, collections from private consumers have never been below 98% while unaccounted-for water has never exceeded 15%. As might be expected, collection from government agencies has been more difficult (World Bank, 1994).

To obtain the full advantages of competition, public entities need to increase the number of private firms interested in contracting for services. This can be done by reducing both ex ante and ex post transaction costs. A recent World Bank study surveyed five European water companies working in Buenos Aires, Argentina; Caracas, Venezuela; Mexico City, Mexico, and Valparaiso, Chile (Richard and Triche, 1994). Not surprisingly, most of their concerns about contracting to provide public services in Latin America involved high transaction costs. For example, the more complete the contract in terms of what the government would and would not do, the more likely the firms were to submit a bid. They wanted assurance in the contract that the government would fulfill its part of the contract. Methods for resolving conflicts particularly with government entities were another important concern. If a country's court system does not work well in resolving conflicts, then the firms wanted some international agency as the mediator. Anything that governments can do to reduce these transaction costs and simplify administrative requirements will increase the number of

private firms bidding and competing for contracts to perform water management activities.

Private well irrigation In some areas, even in the presence of economies to scale and potential externalities, the private sector has taken over leadership in water management. This has been the case in groundwater development, especially for irrigation but also, in some cases, for domestic water supplies. Technology has made available small and relatively inexpensive internal combustion engines for pumps and dramatically changed economies-of-scale and the role of the private and public sectors in irrigation. This advance in technology made it possible for the private sector to use tubewells and low-lift pumps to exploit shallow groundwater aquifers. This was especially important in Asia where the private sector was induced to make major irrigation investments during and 1970s and 1980s.

The extent of government support and the involvement in tubewell development has varied, but in many cases it has involved public tubewells and subsidized electric power, thus eventually leading to overinvestments and overuse of water. In Pakistan, despite emphasis on public tubewells, private tubewells began to spread, at a phenomenal rate of more than 35 percent annually between the mid-1960s and the mid-1970s. Since the late 1970s, government support has been through greater farmer access to credit, diesel fuel, and electricity. Now the government is privatizing many of the public tubewells. In Bangladesh, the growth is quite similar, with private tubewells producing high returns for farm families. In India, the number of wells increased from 0.4 million in 1961 to 6.7 million in 1982. Approximately 95 percent of the area irrigated by groundwater in India is from private wells.

Currently, the major concerns regarding private exploitation of groundwater are aquifer depletion, salinity, monopoly power of well owners, inefficient pumping units, and the inability to integrate surface water and groundwater management. Because groundwater is, in most cases, an open access resource, this is a classic case of market failure when the aquifer capacity is inadequate to accommodate aggregate withdrawals. Indeed, in parts of a number of developing countries, groundwater depletion is occurring. In many countries, groundwater is the property of the land owner under which it occurs and in some areas, land owners and business firms with relatively high incomes are capturing most of the groundwater and the economic benefits arising from its use[4]. Thus, government energy and loan subsidies raise important policy questions. Yet groundwater extraction is costly for governments to effectively control or regulate given the large numbers of wells involved, especially in Asia. Although establishing well defined property rights for groundwater would help reduce the groundwater depletion, implementing such a change in water rights is beyond the capabilities of most developing countries. A better alternative may be for the government to eliminate subsidies and help water users establish groundwater districts that can exercise some control over extraction rates. The basic idea is to have the water agencies provide technical assistance and let the water user internalize the externality by giving them as a group the responsibility and authority to establish groundwater districts and enforce extraction rates for the aquifer.

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[4] In a number of cities such as Bangkok, private pumping, especially by business firms, has drawn down the groundwater table and caused serious problems of soil compaction and the subsidence of buildings.

Water Markets

Another mechanism that can improve water management is the use of water markets. Because of the public good and monopoly concerns, it is not surprising that water markets have not been promoted by governments. Yet with the growing water scarcity, the large differences in water values among uses, and the checkered performance of public water agencies, markets are being considered more widely as a means to improve water allocation and to reduce the economic impact of water scarcity. In contrast to water allocation by administrative decision, market allocations compensate users for decreasing their water use. The allocation is also based on net returns information from individual enterprises that water users possess but that water agencies find expensive to collect.

Water markets are possible when individuals and enterprises have a secure claim to water that is transferable — either through a right, a permit, or a concession. Efficient markets reallocate water so that marginal water values minus transaction costs are equalized. Most water sales involve either the exchange of a finite volume of water or a permanent transfer of water-use rights or concessions. The former — sometimes referred to as a spot market — occurs when the owner of a legal or prescriptive right to a certain volume or flow of water sells or trades a portion of that water, sometimes outside of legal sanctions, to a neighbor in a simple transaction. These exchanges are for a finite period of time — sometimes one irrigation turn. Although the unit of sales may not be metered volumetrically, both buyer and seller have good information on the volume involved. A less frequent type of trade involves the more permanent exchange of water rights. These transfers can be permanent, or for a finite, but extended period of time and the burden of uncertain supply will fall on the purchaser of the right.

Gains from such water trades can be substantial. For example, Chang and Griffin, 1992, estimated gains in trade from water sales in Texas to be from \$3,000 to \$16,000 per 1,000m^3. In Chile, gains from trade arise both from sales within the agricultural sector and between the agricultural and the urban sectors. Net gains from trades in the Limari Valley (Chile) were only \$2,400 per 1,000m^3 since all of the trades were within agriculture. In the Elqui Valley (Chile) where trading between the urban and agricultural sectors is important, the net gains from trade were \$790 per share (each share delivers 1 liter/second in a good year) (Hearne and Easter, 1995).

Even if adequate conveyance structures are in place or can easily be provided, a number of institutional and organizational arrangements are required for water markets to operate efficiently. First, transferable water rights or use rights must be established based on the volume of water owned, or on the share (percent) of a stream or canal flow. These rights should be tradable, recorded, enforceable and separate from land rights. In large river valleys where downstream users are dependent on the return flows of upstream users, these return flows should be accounted for in the water right. Many of these return flow effects could be satisfied by limiting water transfers outside a region to consumptive uses. For example, Mexico's new water law that establishes tradable water concessions is based on consumptive use and has restrictions on the sale of water outside the water district.

In short river valleys such as those in Chile, the return flow issue is less of a concern. In fact, Chile's water law does not restrict the sale of water specified in a water use right to buyers inside the river basin. Although there have been some attempts to change the law, the reduced return flows from water sales have not yet had a significant impact on downstream water users. The one dispute,

so far, has been over the rights to the waste water flows traditionally used by irrigators that was actually the untreated return flows from Santiago's municipal water supply. Once it was determined that the return flows would be treated, Santiago began claiming the rights to sell the treated water. Its claim was then upheld by the Supreme Court in a suit brought by the farmers.

A second important consideration in establishing water markets involves groundwater. Where surface and groundwater are interconnected, problems are likely to occur if rights for surface water are established without doing the same for groundwater. Surface water rights are not secure if someone can install a well next to a canal or river and draw out "your" surface water. The lack of compatible surface and groundwater rights has caused serious water management problems in a number of areas such as Arizona (U.S.) (Charney and Woodard, 1990). In Chile, holders of surface and groundwater rights have a thirty day period in which to file a complaint regarding any potential negative impacts of a petition for groundwater-use rights. If the petition is opposed, the decision whether or not to grant the new water-use right rests with the Director General of Agua (Hearne and Easter, 1995).

Third, because of the different externalities and interdependencies in water use, a system of enforcement and conflict resolution is needed to facilitate trades. Guidelines should be established for dealing with water rights disputes, third party effects, and effluent discharges into water sources. In fact, the same mechanisms for resolving water rights disputes might be used to resolve disputes over contracts to provide water services that were discussed above. In the western U.S.A., both water courts and the Office of State Engineer have helped resolve disputes (Colby, 1990). Water or river basin commissions such as those in France could provide the same service. In Chile, WUAs resolve most conflicts but the Director General of Water has limited power to intervene in disputes.

Much like in the U.S., the ultimate arbiter in Chile is the judiciary, although its effectiveness in resolving water conflicts has been limited by judicial restraint (Hearne and Easter, 1995; and Bauer, 1994).

Fourth, if there are important societal water uses that cannot compete in the market for water, the public sector may need to either purchase these rights or reserve them in the initial allocation of water rights. This might involve water for instream water uses such as the preservation of fisheries or sensitive water-dependent ecosystems. Water quality also needs to be included in the rights or defined by effective government water quality standards. If this is not done, water may be supplied in the quantity established by the water right but the quality may make it unusable for the desired purpose. For example, farmers near some major cities have had problems growing vegetables because the water they receive has been contaminated by sewage discharges that have caused serious health problems when used to irrigate vegetables. Similarly, return flows from U.S. agriculture have raised the level of salinity in the Colorado River to levels that have been unacceptable in Arizona and Mexico. The new water law in Mexico requires users to pay for any reduction in water quality due to their water use. Unfortunately for Mexico, the U.S. does not apply such charges to water users along the Colorado River.

Fifth, the distribution of water rights is likely to be a contentious issue unless defacto or prescriptive water rights already exist and the primary task is to have them formalized. Where prescriptive rights do not exist many countries can avoid conflicts and maintain political support by allocating water rights based on existing land rights. This will work fairly well if the distribution of land is reasonably equitable as was the case in Chile when water was made tradable in 1981. If land ownership is highly concentrated, such as in the central valley of California, where large scale farmers

captured many of the direct benefits from the subsidized public irrigation projects, then an alternative water allocation criteria or land reform is needed. One alternative is to allocate the water rights to all families (landowners and landless) in the irrigated area, as was done with a small village irrigation project in northern India (Joshi and Seckler, 1982). The alternative being used in Mexico is to have the irrigation districts or the WUAs allocate the rights or concessions. This means that the concessions are being allocated primarily based on past use, which is essentially formalizing prescriptive water rights. A complementary alternative would be to allocate some of the rights to the WUAs or a river basin authority and use the sales of these rights to fund the operation and maintenance of the water system. This would probably work only if there was some water not already claimed.

Finally, water systems need to have a certain level of management capabilities to execute the desired trades. Inadequate management increases the transaction costs of trades. The cost of coordinating and administering trades can be a serious barrier to water sales, especially in systems with numerous small scale water users. In water systems where users are larger in scale (municipalities or farms larger than 200 ha.), the users can more easily provide the management needed to coordinate and implement water sales.

Water trades between farmers occur even where the above institutions are not in place. For example, in the Indian subcontinent, neighboring farmers trade hours of canal water flow or sell hours of pumping time. Informal markets have developed in the large surface water systems of Pakistan and northern India among farmers along a given water course or canal (Easter, 1986). Farmers have a use right to a certain time period for irrigation from the watercourse that serves their area. The actual volume of water received will vary depending on the water flow but whatever the

flow is during the farmer's allotted time for irrigation is his to use. The trades are made for all or part of an individual irrigation time allotment. Yet, even on an individual watercourse, the coordination required among farmers can make it difficult to transact trades. If there are other farmers on the watercourse in between the two farmers who want to trade, then the intervening farmers must also agree to the change in irrigation time. The fact that such water trades are illegal makes it difficult if not impossible for the government officials to help in the coordination. Still numerous trades occur, indicating that both buyers and sellers receive significant benefits from these trades.

Informal markets exist for groundwater in countries such as India where land owners have the right to pump any water they can from under their and their neighbors' land. The open access to groundwater and subsidized energy prices have encouraged farmers and others to begin selling groundwater to farmers located near their wells. "Up to half or more of the land served by private modern well extraction mechanisms in many parts of India is likely to be owned and operated by the buyers of water" (Shah, 1993, pp. 48-49). This practice is encouraged by the pricing policies of State Electric Boards which charge flat fees for each pump instead of a charge for the quantity of power used. In areas with a marginal pumping cost that is close to zero and no barriers to entry, the pump owners' selling price is driven down through competition, and remains low, and near the cost of pumping (Palanisami and Easter, 1991 and Shah, 1993). In areas with limited groundwater stocks, water levels are falling and well owners must deepen their wells or stop irrigating. As would be expected, water prices are much higher in these areas and above pumping costs because of the high scarcity value of the groundwater. In areas with salt water intrusion, rapidly declining groundwater tables, or aquifer compaction, market prices fail to reflect the externalities caused by pumping and, therefore, water markets have increased the rate at which the aquifers are damaged in these areas.

But in the areas where canal irrigation has caused waterlogging or where groundwater is readily recharged from monsoon floods, increased groundwater pumping has produced major economic benefits for India (Shah, 1993).

Some of the institutional arrangements may not be necessary if a country has the infrastructure to take a more centralized approach to marketing water such as the system of selling water which was established in California during 1991. This "Water Bank" takes advantage of the state's extensive system of canals and allows entities with high valued uses for water to purchase finite quantities of water from low valued uses. Despite the fact that actual purchases were limited, municipal areas were able to ensure water supplies during the last part of a severe drought. Because transfers of water were volumetric and temporal, sellers were not threatened with forfeiting their permanent water rights. Thus the political difficulties of permanent water transfers were minimized while the economic incentives of water markets were introduced.

Water User Associations

Water user associations are another mechanism for introducing private consumer incentives and they can be given a wide variety of rights and responsibilities. Historically, there is a great deal of literature that discusses the detailed workings of informal WUAs that were established with little or no assistance from government. More recently, the interest has shifted to those WUAs that have been or are being established to play a larger role in the management of public or public financed water systems. The idea is that by having the users more directly involved in water management decisions, that there will be greater incentives to improve water use. One good example of what is possible if the major beneficiaries are included in the WUA is the successes that have been achieved in improving water supply and sanitation services in rural areas of Kenya and Bangladesh (Box 1).

In both cases, women became key players in the WUAs. For the 135 WUAs in Kenya, all had women as treasurers. Women were also trained as extension workers, community organizers, and to do any needed maintenance or repair of the water systems. Both areas had significant improvement in health and reduced time spent in collecting water.

WUAs can also be important in facilitating the efficient operation of water markets. In Chile they are important factors in reducing the transaction costs of water sales. They usually make any changes in control structures that are required for water sales but the cost of making the change is paid for by the entity buying the water. The associations are also important in resolving conflicts and conveying information about potential buyers or sellers of water.

Associations can be involved in contract work with government water agencies or private firms. For example, irrigation agencies have contracts with WUAs to collect fees, maintain canals, and provide other water services that irrigation agencies have provided in the past.

Although the record of WUAs in terms of improved irrigation performance is mixed, the contracting with WUAs has, at a minimum, reduced the administrative costs for the irrigation agencies, reduced damages to structures, and increased fee collections.

Water user associations have also been promoted as a means to deal with some of the public good and open access problems associated with water projects. Water users should have an incentive to improve their system's performance and have better access to information concerning water demands and water use. Again, their performance record is mixed.

Box 1. Women and Water Supply and Sanitation

Two recent projects demonstrate the effectiveness of community-based approaches for providing water and sanitation services. Both emphasize community participation and include primary roles for women.

In the southern coastal area of Kenya, a project to develop and install a system for hand pumps was begun in 1983. Early problems prompted the organizers to bring in a local NGO specializing in developing self-help water systems and focusing on women's participation. Women were trained as extension workers and in community organizing and development. Both men and women were trained for the appropriate maintenance and repairs. The local NGO motivated village men and women to organize themselves into water committees which would be responsible for maintenance and repairs. By 1988, 135 village water committees existed, all of which had women as treasurers. All of the pumps were functioning. Both men and women had gained greater self confidence and had an increased respect and acceptance for women in public decision making. In the project area, between 1985 and 1987, there was a decline in diarrhea and skin diseases. The project also resulted in savings for both government and the villages.

In Mirzapur (Bangladesh) a program set out to install hand pumps and latrines. Again, the project was designed to be community based, with a strong emphasis on the inclusion of women. Women were involved from the beginning in selecting sites for hand pumps and latrines. Women helped cure the cement for the platforms and were trained in maintenance of both the pumps and latrines. Women were also the main focus of the hygiene education program. In the intervention area, 148 Tara hand pumps were installed (1 for every 33 inhabitants) and 754 latrines. Ninety percent of the households used the hand pump for practically all domestic use compared to only 20 percent outside the intervention area. Ninety-eight percent of the adult population said they used the latrines regularly. Within the intervention area, there was a noticeable decline in diarrhea and other diseases. Essential to all of this was the strong participation of the women.

Both of these projects recognized that women would not automatically become involved, instead a determined effort was necessary to ensure their involvement. The implementing agencies recognized the male agreement was necessary and thus neither project excluded men. This demonstrated that not only were communities able to manage water supply and sanitation systems on their own, but that women were capable and willing to take over major management responsibilities.

Source: World Bank, 1993.

Farmers have been willing to take over responsibility for water management with and without the governments' requests. Even before it became the Mexican government's policy to transfer management responsibility to farmers, a group of farmers took control of a canal in western Mexico. The farmers served by the canal asked the irrigation agency to enlarge their outlet, but received no response, positive or negative. Consequently they collected funds and did the work themselves. The farmers now consider the canal theirs and will not allow agency people to enter the area (van der Zaag, 1992).

Such independent action by water users is to be applauded as long as the enlarged outlet does not deprive farmers downstream of their water concession. If all groups of farmers along the canal

enlarge their outlets, users at the end of the canal will have their supplies reduced. Thus, although WUAs play an important role, there must be a mechanism for oversight that helps users understand and take into account the effects their actions have on downstream users.

This could be done by establishing and allocating water rights or concessions to the WUAs as is being done in Mexico. Such rights should specify how much or what share of the water in the main canal is allocated to each group. If expanding the outlet would allow a group to exceed its concession, the other WUAs could take legal action to stop them form changing the outlet. This, of course, requires an effective legal system or other mechanisms to resolve water conflicts, which many countries do not have.

There are other cases where farmers have resisted taking over responsibility for managing any of the irrigation system. Farmers say it is the government's system, and the government should operate and maintain it (Box 2). These are generally systems built without any input from users and designed to meet broad national policy objectives such as increasing food grain production so that food prices are kept low. In fact, some of these systems may be, at best, only marginally beneficial to farmers who can produce more but have to sell at low prices. Thus, they have little increase, or no increase in net farm income and little incentive to help operate and maintain the system.

A number of factors have been identified that help WUAs take over more responsibility for water systems and improve performance. Two are critical and are necessary conditions for the sustainability of WUAs. The first is that water users must benefit from forming WUAs and taking over responsibility for water management. Social pressure might help get a few users to belong who do not receive benefits, but the majority of the members must receive significant net benefits over time if the WUA is to be sustainable. The other important condition is that users need to feel a sense

Box 2 Farmers' Preferences for Agency Management in Zimbabwe

In a recent study of irrigation system performance in Zimbabwe (Rukuni, Svendsen and Meinzen-Dick 1994), over seventy percent of farmers on sample systems managed by either Agritex (the government agency responsible for smallholder irrigation development) or community groups reported that they would prefer to have Agritex manage the systems, even if it meant paying twice the existing irrigation service charges. Indeed, during the study year, one community-managed system petitioned Agritex to take it over, because problems with system infrastructure and divisions within the irrigation association became too great for the system to continue functioning.

Several factors contributed to farmers' reluctance to assume full management control, even on the small systems. First, farmers' cash costs of managing the systems are likely to exceed even twice the prevailing irrigation service fees, especially on systems with pumped water supplies. Second, Agritex does a relatively good job of managing systems, and of providing extension services and advice to smallholders on the schemes. Third, WUAs are likely to have difficulty in obtaining repair services in the remote areas in which many smallholder schemes are located. Finally, many farmers reported that they did not feel their WUAs were capable of carrying out many of the management functions, or did not wish to deal with conflicts amongst themselves.

Source: Meinzen-Dick, et al., 1994.

of ownership for the water system. Clearly such a sense of ownership was established when the water users in western Mexico enlarged the canal outlet after the irrigation agency did not respond to their request.

Another factor that is important in effectively utilizing WUAs is clearly defined rights and responsibilities. Just like establishing complete contracts with private firms, government agencies need to have contracts with WUAs. These should spell out what the government will do and what is expected of the WUAs. Moreover, like private firms, the WUAs want assurance that the government will fulfill its contract and obligations. If government agencies do not fulfill their tasks such as delivering water to the outlets in a timely manner, the WUAs will have a difficult time improving performance (Easter, 1993).

As was found in a study of irrigation performance in Zimbabwe cited above, farmers looked to the government to solve the operations and maintenance problems that were beyond their capability. In Mendoza, Argentina, a different approach was taken. The WUAs consolidated so that

they could take advantage of economies-of-scale and hire their own private professional managers to operate and maintain the systems. The traditional systems were only 100 to 500 ha in size. When the WUAs were able to merge, the size jumped to 3,000 to 15,000 ha. The results of the consolidation are encouraging. Administrative costs are now lower and conveyance efficiency has been increased by 10 percent through improved water distribution (Chambouleyron, 1989).

Associations in Mexico appear to be following the same path of hiring professional staff to take over operation and maintenance responsibilities from the government. The ability to hire and provide incentives for their water managers was also critical for the effectiveness of Taiwan's irrigation system. As Martin Abel, 1977, reported, "a distinctive feature of the irrigation of Taiwan is that the systems are essentially owned and managed by the farmer-users of the water. Thus, the managers of the irrigation systems work for the farmers... Even when some members or management are appointed by government, they are expected to be responsive to the needs and desires of the members of the irrigation association" (Abel, 1977, p.40).

V. Summary and Conclusions

Although decentralizing or unbundling water management activities and improving incentives and accountability cannot solve all of the problems facing the water sector, such efforts have improved the efficiency of water allocation in a number of countries. When given adequate economic incentives, responsibility, and authority, WUAs have effectively taken over activities commonly done by government agencies at a savings to tax payers. Water markets offer the added potential benefit of improving water efficiency within the sector as well as providing a mechanism

for reallocating water among sectors. Contracting and leasing for water services by public agencies have also helped improve the effectiveness of water management.

What can other countries learn from these attempts to decentralize water management and use private sector incentives? Where water is scarce, countries should seriously consider incurring the expense of establishing water markets and WUAs. In some countries, private arrangements for water trading already exist among farmers, even where trading is illegal. Thus a first step in these countries would be to make water trading legal. In other countries, it probably would not be too costly to establish private water use rights based on existing water use. The key question is whether or not governments would be willing to give up control over water transactions as the government of Chile has, and focus on oversight responsibilities including conflict resolution, regulation, and water quality improvement. A middle ground might be to start out by contracting for services and by making greater use of WUAs.

The Mexican law offers another possible compromise alternative, where markets are primarily allowed to operate freely within irrigation districts or water user associations. Intersectoral trades are subject to regulation by the Commission and approval of the irrigation districts. A similar strategy could be tried in other countries. This would allow governments to maintain a greater role in water planning and allocation while still encouraging market based improvement in water use at the district and sector levels.

Markets might also be used to improve both intracountry and intercountry water allocation. For example, a system of annual or seasonal water sales similar to California's water market might by used by countries in a river basin to help modify the impacts of localized droughts. An international water commission could be established for the basin to facilitate such trades. This would

not necessarily involve permanent transfer of water, but could be restricted to exchanges for a limited amount of time such as one crop season. These trades could offer large economic benefit to both the buyers and sellers.

Countries need to consider alternative ways they might use more private incentives to improve water management. If they can take steps to reduce transaction costs associated with such activities, contracts for service, WUAs and water markets can be effective mechanisms for improving water management. Yet these mechanisms alone will not bring about a socially optimal distribution of water. Governments will have to take an active role in protecting third party rights, in regulating monopolies, in improving water quality, and in resolving water use conflicts.

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