

## Who pays for irrigation: cost recovery and water pricing?

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### Abstract

The objective of this paper is to develop guidelines for improving cost recovery and reducing water use per unit of output. The guidelines were developed from a review of studies of irrigation reforms and interviews with World Bank staff members who have responsibility for irrigation sector reforms. From these studies and interviews, we distilled specific reforms that were important in improving cost recovery or reducing water use, or both. The paper lists the reforms that have raised collection rates and provides examples of what different countries have done to recover project costs and collect water charges. It also suggests alternatives for designing water charges that will give farmers an incentive to make better use of their water. The final section provides a summary of the reforms that are important for increasing costs recovery and encouraging farmers to improve their use of water.

*Keywords:* Cost-sharing; Cost-recovery; Economic efficiency water pricing; Institutions: participation and financial autonomy

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### Introduction

As Jones' study in 1995 illustrates, cost recovery and charging for irrigation water has been a challenge for public authorities for decades. Depending on what costs are included and how the costs are allocated for various purposes, federal irrigation projects in the USA are lucky to recovery 20% of their costs from farmers. In developing countries the record is no better. For example, Nepal and Sri Lanka have had collection rates of 20% and 8%, respectively (Easter, 1993). The low levels of cost recovery and water charges have had a number of adverse impacts. For example, the lack of funds has been a major reason for the poor operation and maintenance and declining productivity that has plagued many irrigation projects in developing countries (Easter, 1993). This decline in productivity has been exacerbated in some areas by rising water tables and growing salinity problems caused by over-irrigation. When water is cheap and the timing of water delivery is uncertain, farmers over-irrigate when

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they have the opportunity. This leads to a poor allocation of water as farmers at the top of the system and the head of canals over-irrigate while those at the end of the system may receive little or no water.

In charging for public irrigation water there are generally two objectives. The first is to collect enough in water charges from farmers so that the irrigation system can be effectively operated and maintained. Without such collections the projects are not sustainable over time unless large government subsidies are available. The second objective is to design water charges so that farmers have an incentive to conserve water. In some projects, particularly large projects in developing countries, this second objective is difficult if not impossible to implement since water charges are seldom related to the amount of water individual farmers receive.

In this paper, we first briefly examine the reasons for low cost recovery, before reviewing the argument regarding what costs to recover. This is followed by a section discussing pricing mechanisms for cost recovery. The fourth section discusses a wide range of practices that have helped improve cost recovery or reduced water use in a number of successful projects. The final section distills policy recommendations from these successes<sup>1</sup>.

### Why cost recovery is low

There are a number of reasons why cost recovery has been so abysmal in so many areas. The following are the most important of these reasons: (1) there is no link between fees collected and funds allocated to a given irrigation project, (2) there is a lack of farmer participation in planning and management of projects, (3) poor communication and lack of transparency between farmers and irrigation management, (4) poor delivery of water services (timing, duration and quantity are inadequate), (5) there are no penalties for managers and staff who provide poor service, (6) there are no penalties for farmers who do not pay water charges, (7) the low priority given to fee collection, efficient water use, or system operation and maintenance (O&M), (8) inappropriate infrastructure design and technology to manage the irrigation system effectively and (9) corruption among irrigation officials and those collecting water charges. Many of these reasons for low collection rates and cost recovery stem from the collective good nature of water projects, combined with open access to water resources, and principal agent problems and the rent seeking activities of irrigation officials. It also can be thought of as an assurance problem: assurance for managers concerning what water users will do and assurance for water users concerning what water managers and their staff will actually do as opposed to what they say they will or can do given the existing project design and technology (Easter, 1993).

The dominate reasons for low cost recovery will vary between countries and even between projects within a country. The problem is to develop a strategy that deals with the problems of a particular country or project. Although there will be common elements across countries and projects with successful cost recovery, we cannot develop one model that fits all.

<sup>1</sup> These successful projects along with others are reviewed in greater detail in an Agriculture and Rural Development Discussion Paper 20, published by the World Bank (Easter & Liu, 2005). In its Appendix, it summarizes over 30 projects and studies used in the analysis.

## What cost to recover?

One aspect of cost recovery is clear; it involves more than just raising fees or spending more to collect the water charges. We really need to start at an earlier stage and clearly agree on what costs to recover and what mechanisms to use to recover them. A number of mechanisms are available to charge for water, varying from area base water charges to volumetric charges based on the actual water delivered. In deciding what costs to recover, at least three types of costs should be considered: direct project costs, environmental costs and marginal user costs.

Direct project costs are the easiest of the three to measure and most projects only consider direct costs when determining what costs to recover. Direct costs refer to the costs of capturing and delivering irrigation water, which can be divided into fixed costs and variable costs. Fixed costs include all costs of establishing irrigation infrastructures such as building reservoirs and canals and installing meters and pumps. Higher level administrative costs and some operational and maintenance costs not involved in actual water delivery are also considered fixed costs because they do not vary with the amount of water delivered or whether or not delivery occurs (drought years, for example). Variable costs consist of the operating and maintenance costs of water delivery, lower level administrative costs (usually temporary labor costs during the time of water delivery) and the costs of supplying water, which include conveyance costs, groundwater extraction costs and the costs owing to water losses. These costs vary with location, water delivery method, irrigation technology and season (Massarutto, 2002).

Environmental costs include soil erosion and damage to the surrounding ecosystem during and after the construction of an irrigation project as well as water-logging and salinity problems caused by the irrigation. Yet, few irrigation projects in practice include environmental costs as part of the cost to be recovered. Including environmental costs could substantially raise the total costs of many irrigation projects. South Africa is developing a system of charges that will reflect and recover direct and indirect costs associated with the discharge or disposal of waste. The charges will include a load-based charge proportional to the waste load. Initially, this charge will relate to salinity, nitrates and phosphorous in the water discharged. An extra charge will apply if the waste load exceeds the maximum permissible level. Also, rebates will be provided for returning water to the source at a higher quality than when it was abstracted (Republic of South Africa, 2004).

In South Australia, the government has agreed to cover the costs of salinity management caused by pre-1988 irrigation development, while farmers (irrigators) will be responsible for the salinity costs associated with all the post-1988 irrigation development. In addition, the current two-part price structure can be adapted to accommodate environmental externalities. When infrastructure has to be renovated or built to reduce water quality-related externalities, the fixed costs can be captured in the fixed portion of the two-part price. Quantity-related externality costs can then be included in the volumetric portion of the two-part price (Bueren & MacDonald, 2004).

Marginal user cost is defined as the present value of future sacrifices caused by current resource use (Howe, 1979). It involves the higher costs of obtaining future water supplies because more accessible and less expensive water resources are used up first. In an extreme case, a water resource is completely used up in the current period. This cost is especially important for groundwater resources with little or no recharge. Excluding marginal user costs in the price of such groundwater often results in overuse of the resource. However, one reason user costs and environmental costs are generally not included in water charges is that they are difficult to estimate and may be beyond the knowledge of many countries.

After determining which of these costs to include, the next concern is what percentage of total costs should be allocated to farmers. In many cases, who should bear the costs of providing irrigation water is not clear. Whether the farmers should pay the full costs depends on factors including project objectives and the extent of benefits that accrue to groups other than irrigating farmers. Irrigation projects serve multiple beneficiaries in two major ways. One case is multipurpose projects; the other is projects involving the indirect beneficiaries of the increased agricultural production.

Multipurpose water projects are quite common. Apart from supplying irrigation water, projects may supply water for household and industrial uses as well as provide flood control, navigation and hydropower. In Asia, 90% of dams for irrigation are multipurpose. In these cases, it seems appropriate that the different users should share the costs in proportion to the services they receive. There are three common methods used to allocate costs among users: the use of facilities (UOF), alternative justifiable expenditures (AJE) and separate costs, remaining benefits (SCRB) methods (Young *et al.*, 1982; Young, 1985; Easter, 2003). The first approach, UOF, allocates costs among different types of users sharing the same facility in proportion to the water delivered to each type of user (e.g. irrigation and domestic water supply). The second approach, AJE, allocates joint costs based on remaining benefits after subtracting specific costs, where specific costs refer to costs directly attributable to a single purpose (e.g. irrigation). The third approach, SCRB, is similar to the second one, but it is more difficult to calculate since it relies on separable<sup>2</sup> costs rather than specific<sup>3</sup> costs. It assigns costs that serve a “single” purpose to the benefiting purpose, including the costs of any project design changes required to include the added purpose. The remaining “joint” costs are assigned in proportion to the remaining benefits derived for each type of use after subtracting the separable costs.

An irrigation project in Andra Pradesh, India, provides a good example of how the costs from a multipurpose water project may be allocated between different types of uses or purposes (Table 1). Two alternative cost allocations were calculated for the distribution of project costs. The first allocation is based on the quantity of water delivered for each purpose or use. Since the allocation is based on water delivery, only the three consumptive water uses are allocated a share of the costs, with between 95% and 98% of the cost allocated to irrigation (part A). When costs are allocated based on benefits generated, all five major direct beneficiaries are allocated costs and the share for irrigation drops to between 88% and 94% (part B).

In projects with large indirect benefits, some of the costs may be allocated to the indirect beneficiaries. For example, in countries where the government pursues a low food price policy, food processors and consumers both may benefit more from irrigation improvement projects than farmers. In such cases, paying part of the project costs with tax revenues collected from the benefiting consumers and processors might be one good means of helping to fund the project.

The Sana'a basin water management project in Yemen illustrates cost allocation when a major objective of an irrigation improvement program is to reduce the rate of groundwater exploitation, a

<sup>2</sup> Separable costs in multipurpose projects are the extra costs that are incurred when an additional purpose is added to a multipurpose project. If irrigation is added as a project purpose, the separable costs would be the cost of the irrigation canals plus the costs of increasing the reservoir capacity. The latter cost is not a specific cost, but it is separable in that the reservoir would be smaller without the irrigation purpose. The separable costs are calculated by comparing project costs with and without each purpose separately.

<sup>3</sup> Specific costs in multipurpose projects are the project components and costs that are specific to only one purpose such as the cost of a pipeline to deliver water to a city.

Table 1. Alternative cost allocation for three water projects in Andhra Pradesh, India.

Part A. Cost allocation for three consumptive uses based on water delivery			
Three water projects	Domestic water supply (percent)	Industrial (percent)	Irrigation (percent)
Nagarjursagar	2	0	98
Tungabhadra	1	4	95
Sriram Sagar	2	3	95
Part B. Cost allocation among three projects based on direct benefits			
Purpose or use	Three water projects Sriram Sagar (percent)	Nagarjursagar (percent)	Tungabhadra (percent)
Irrigation	88.1	94.3	91.3
Hydropower	3.0	4.0	4.2
Domestic	3.0	1.6	2.1
Industry	4.3	0.1	2.3
Fisheries	1.6	0.1	0.1

Source: World Bank, 2003b.

benefit that users will only realize in the distant future. The strategy is to reduce the speed of groundwater mining by subsidizing water conservation practices and extend the useful life of the aquifers to give the government time to find long-term solutions. To do this, the government introduced piped conveyance and distribution systems, as well as drip irrigation technology, in the pilot areas. Irrigation efficiency was improved from 35% to 60%. To encourage adoption, government covers 75% of the investment costs and 90% of the installation costs; farmers are responsible for the remaining costs. Farmers also pay 100% of the O&M costs. Such cost sharing rates have encouraged more farmers to participate in the project and reduced the amount of water used per hectare (World Bank, 2003a).

## Pricing mechanisms

Along with deciding on the cost allocation, another part of cost recovery is designing an effective pricing mechanism to collect the costs. In selecting a collection mechanism one must decide if the charges are just to collect costs or if they are also supposed to encourage farmers to conserve water. Not surprisingly, designing water charges just to cover project costs is easier than trying to cover costs and encourage conservation. There are basically three major methods for pricing water; area-based charges, volumetric charges and market prices, of which the latter two provide the best incentives for water conservation.

### *Area-based charges*

Area-based water charges are fixed charges, based on the area irrigated or “supposed” to be irrigated. They are often calculated by dividing the total area irrigated into the O&M costs of providing irrigation water, which basically follows the average cost pricing principle. What to include in the O&M costs is a key question because the water supply entity may have an incentive to inflate the costs charged to

farmers. Another question is what irrigated area to use because it may vary from year to year and season to season. For example, the area irrigated during the wet season is usually much larger, but less intensely irrigated, than during the dry season. In addition, the project area is usually larger than the area actually irrigated in many developing countries.

The disadvantage of this pricing method is that once the irrigated area decision is made, the water charge will have no effect on farmers' water consumption, because the marginal cost of applying additional quantities of water per hectare is almost zero. Thus, the demand for water is usually higher than it would be under a price or charge that varied by the quantity of water used, and such area-based pricing is likely to lead to overuse of water particularly by farmers in the upper part of the irrigation system. The advantage is that it is simple to calculate, easy for farmers to understand and the implementation costs are lower than for volumetric pricing because water deliveries do not have to be measured.

Pure area-based charges are appropriate in places where water is not scarce, where crops are not varied and where meter installation is difficult or costly. However, pure area-based charges are becoming less and less popular and most of the recently designed area-based systems are adopting new features. The extensions include area-crop (the most widely used modification), area-season and area-technology-based pricing. Area-crop-based pricing systems vary the charge per hectare by type of crop. If policymakers want to encourage water conservation, high water-consuming crops such as rice, would face higher water prices per hectare. If the price differences are large enough, farmers are likely to switch to alternative crops which require less water.

Some countries also use area-season-based charges. For example, a higher price is charged during the dry season, when water is scarce and a lower price is levied in the monsoon or wet season when water is relatively plentiful. If the price is set high enough in the dry season, it will help limit the number of hectares irrigated in that season. In France, the pricing structure is based on different costs for off-peak and peak water use. The peak season lasts five months in the summer and the water price reflects the long-run marginal cost of supplying water. During the off-peak seasons, only operating costs are included in the price (Johansson *et al.*, 2002; Tiwari & Dinar, 2003).

Another possible combination is area-technology-based pricing. Although it has not received much attention, theoretically it could promote selected irrigation technologies. The basic idea is similar to area-crop-based charges, with farmers using water-saving technology paying lower per hectare water charges. For example, drip and sprinkler irrigation generally allow better water control and more output per unit of water delivered than flood irrigation systems. Therefore, a higher per hectare water fee could be levied on farmers not using these water conserving technologies to encourage them to switch.

### *Volumetric pricing*

With volumetric water pricing, the charge is based on the amount of water delivered. The economic optimal pricing rule requires that price should be set equal to the marginal cost of providing the water and it requires accurate measurement of water through meters. The advantage of this pricing method is that it encourages farmers to limit their water use. Also, it is easy to understand in the sense that you pay for the quantity of water you are delivered. However, it has several disadvantages. First, the implementation costs can be high because meters are usually required and they have to be honestly read and reported. Second, marginal cost pricing does not allow full cost recovery in the case of decreasing



average costs (e.g. in large canal systems). Once the infrastructure is in place, the marginal project costs will be lower than average costs, thus pricing based on the marginal cost will not achieve full cost recovery. In contrast, for the case of pump irrigation using groundwater, the marginal project costs are likely to be higher than average project costs, particularly when marginal costs include the marginal user cost. Thus, for some groundwater projects, marginal cost pricing could result in collections exceeding total costs.

Block pricing can be used to deal with these pricing problems. It involves varying the water price when water use for a given time period exceeds a set volume (e.g. 5,000 m<sup>3</sup> per hectare per season)<sup>4</sup>. If high water charges are a concern, increasing block charges can be used. The price of the first block can be set below O&M costs. The second and later blocks can then be raised to higher rates that cover O&M costs and reflect the marginal cost of operations. The amount of the first block is often considered the basic amount of water needed to support a farm family, so this method can also be used to address equity issues. Farmers pay a low rate for the first block but a much higher price for any water used that exceeds the first block. This pricing method operates similarly to a quota. In fact, a quota is an extreme case of increasing block pricing. Even when an official quota exists, farmers can usually obtain additional water by paying irrigation officials or private sources a high enough price. The advantage of the two-block pricing is that you have, at least, three instruments to influence water use and cost recovery: the first and second block prices and the quantity (e.g. 4,000 m<sup>3</sup>/ha versus 5,000 m<sup>3</sup>/ha) at which to start the second block price.

The two-part charge is a second modification, which is a combination of volumetric pricing and a fixed admission charge (sometimes based on size of the area irrigated). For the block pricing methods described above, the two objectives—full cost recovery and reduced water use—are often in conflict. The advantage of a two-part charge is that it can reconcile the conflict. The volumetric part can be based on marginal cost, which encourages water conservation, while the fixed part can be used to make up any deficits and ensure a certain revenue flow regardless of how much water is available and delivered. Even for O&M costs, there is a fixed component which does not depend on the amount of water delivered and these fixed costs have to be paid even when water is not used. The disadvantage is that prices are relatively harder to calculate and difficult for farmers to understand.

### *Water markets*

In countries with either formal or informal water markets, companies or individuals can trade water at a particular market equilibrium price which may change throughout the season. To operate effectively, water markets require a well-defined structure of water rights, a clear and comprehensive set of rules for trading, an entity to manage water delivery and oversee trading activities and a judicial or administrative body to resolve disputes. They also require a well-developed conveyance system for transporting water to all participants (Tsur & Dinar, 1998). If these requirements are in place, market equilibrium prices will effectively adjust supply and demand and reflect the scarcity value of water. Such prices will encourage water conservation and can recover project costs if the water is sold by the entity managing

<sup>4</sup> When equity is a major concern, the block rate could be based on the total amount of water delivered to a farmer per season. Thus, large-scale farmers would have to pay higher charges, since they irrigate more land and must use more water.

the system. There are a number of successful cases of water markets around the world, such as in Chile (Hearne & Easter, 1995), Australia (Bjornlund & McKay, 1998), the Siurana-Riudecanyes irrigation district in Spain (Tarrech *et al.*, 1999), the Cariri region of Ceara state in northeast Brazil (Kemper *et al.*, 1999) and Northern Colorado in the USA (Kemper & Simpson, 1999).

### Cost recovery and water pricing strategies

An essential part of any cost recovery or water pricing strategy is its implementation. One means of improving implementation is to review successful projects or countries and determine what factors are important in their success. Such a review suggests there are a number of key factors that have improved cost recovery and reduced water use.

#### *Keys to improving cost recovery*

Two basic steps are necessary to achieve cost recovery: the first is to design a pricing mechanism that covers the appropriate costs; the second is to achieve high collection rates through effective water management. The design involves working with water supplier and farmers to determine what should be included in the costs and which of these costs should be collected through a water fee rather than through other taxes such as a land tax or a local property tax. Once this decision is made, setting the appropriate fee level becomes basically an accounting problem that is influenced by the type of irrigation system and ability to measure and monitor water use. As discussed above, when the volume of water delivered cannot be measured, water charges are usually based on some measure of area irrigated. Sometimes the area-based charges are adjusted to account for the crops grown and the season of the year. Once the appropriate level and type of water charge is determined, the more difficult step still remains—achieving high collection rates.

A key to achieving high collection rates suggested by both the literature and field experience is some level of financial autonomy (Easter & Liu, 2005). Without financial autonomy, collecting sufficient funds from users does not guarantee improved O&M because revenues from water charges usually do not go back to the project but are commingled with other taxes in the central treasury. This probably explains why Jones (1995) found that, in many projects, there is no direct relation between water charges and the service quality. Shifting irrigation project management to a financially autonomous organization creates a financial incentive for improving irrigation services. Better services give farmers an incentive to pay their fees, as well as an increased ability to pay because better service means higher crop yields and farm incomes. Financial autonomy can provide a positive feedback system through a direct financial link between farmers and the service delivered by water suppliers.

The Yangtze Basin Water Resources (Yangtze) project is a good example of an effective autonomous water management entity. The Yangtze charter required direct involvement of Water User Associations (WUAs) in water management and decision making. To improve cost recovery and conserve water, incentives were implemented through volumetric water pricing, improved water delivery and a reduction in the irrigation time cycle. On average, each WUA has saved over one million cubic meters of



water annually and increased productivity. After the introduction of WUAs, average crop yields increased by 6% of which 40% was due to the improved irrigation (Lin, 2003).

Financial autonomy also ensures that revenue from water charges will revert to the project. Service providers no longer receive subsidies from the central government, which means they have to collect water fees from users to recover their costs. In such cases, they are likely to create incentives to achieve high fee collection rates. Some suppliers strictly enforce penalties against payment defaulters (Table 2). In Bayi Irrigation District, China, irrigation water is cut off from payment defaulters until they pay their debts (Johnson *et al.*, 1996). In Shangdong, China, the use of integrated circuit (IC) machines insures that farmers cannot obtain irrigation water without paying. Farmers must purchase a prepaid IC card to operate the IC machine that measures and controls the water release (Wang & Lu, 1999). Using IC machines is an innovative way to collect charges, which gives farmers full control over water use and also effectively enforces payment collection. This system reduced water use per hectare and achieved 100% collection rates at the same time<sup>5</sup>.

Incentives both to pay and to collect the fees help increase cost recovery. In Haryana, India, land can be taken away from people who do not pay their water fees (Cornish & Perry, 2003). An example of suppliers creating awards or penalties to encourage staff to achieve high collection levels is found in Awati, China. They make staff salaries completely dependent on the water charges. Since they do not receive any government funding, staff salaries must come from revenues collected from farmers. Collection rates reached 98% after the institutional reform that established the financially autonomous management entity (Awati County Government, 2002). In Bayi Irrigation District, China, staff members receive rewards for turning in the collected fees by a set deadline and are fined for late payments (Johnson *et al.*, 1996).

User participation throughout the entire irrigation management process through local WUAs appears to be another important factor in high collection rates. Farmers are more likely to pay if they are involved in a transparent decision-making process and the earlier the involvement, the better. In fact, they are more likely to be willing to pay for system improvements that they help design and build. Coward (1980) cites the Laur project in the Philippines, where the WUA had a chance to scrutinize the irrigation agency's rehabilitation design and expenditures on their project. He found the irrigation agency gained in terms of improved design as well as a local commitment to pay for the project.

The irrigation management transfer in Indonesia, started in 1987, also illustrates the benefits of involving farmers in planning, especially in the preparation stage of renovation or new project construction. Joint project walk-throughs, where farmers have the opportunity to walk through and discuss project with managers, were found to be the single most effective technique for communication and cooperation. It allowed farmers to suggest their top priorities and concerns for improving O&M and has generated more farmer interest and contributed to better design of the projects (Bruns & Helmi, 1996). In addition, it is important that farmers are involved in cost-sharing decisions and in decisions concerning what costs are to be recovered. In the Indonesia and Philippines examples, cost sharing appears to have provided farmers with a strong incentive to insist on higher quality construction that better serves their needs. They began treating the project as their own. Almost every successful case in

<sup>5</sup> Although the article does not identify the water source, it appears that all of the systems with IC machines involve farmers using pumps to obtain their irrigation water.

Table 2. Factors influencing fee collection rate.

Cases	Financial autonomy	Incentives to collect	Incentives to pay		User participation	System transparency	Collection rate (percent)	Source
			Penalty for non payment	Improved irrigation service				
Awati, China	Yes	Yes	N.A.	N.A.	Yes	N.A.	98	Awati County Government, 2002
Bayi ID, China	Yes	Yes	Yes	Yes	Yes	Yes	100	Johnson <i>et al.</i> , 1996
Nanyao ID China	Yes	Yes	N.A.	N.A.	Yes	N.A.	95	Johnson <i>et al.</i> , 1996
Shangdong China	N.A.	N.A.	Yes	Yes	N.A.	Yes	100	Wang & Lu, 1999
Yangtze Basin, China	Yes	N.A.	N.A.	Yes	Yes	N.A.	N.A.	Lin, 2003
Gujarat, India	Yes	Yes	Yes	Yes	Yes	N.A.	100	Cornish & Perry, 2003
Haryana, India	Partly	N.A.	Yes	N.A.	Yes	N.A.	85–95	Cornish & Perry, 2003
Mexico	Yes	N.A.	Yes	Yes	Yes	N.A.	90	Zekri & Easter, 2003
Alto Rio Lerma, Mexico	Yes	Yes	N.A.	Yes	Yes	Yes	100	Kloezen <i>et al.</i> , 1997

N.A. Not available.

**Table 2** involves some type of local user participation in water management, suggesting that it is likely to be a necessary reform to improve cost recovery.

Mexico is another recent case where there have been major improvements in water fee collection after the management transfer to water users. After experiencing serious problems with water delivery and fee collection, Mexico in 1990 began a program to set up and turn over management and tradable water rights to WUAs. By the end of 1997, 400 WUAs were operational and each controlled an average irrigated area of 7,600 ha. Surveys conducted in 6% of the districts showed that water use per hectare had been reduced and maintenance improved. Water charges went up in most districts owing to the financial self-sufficiency target, increasing more than 500% in some cases. Many WUAs have made significant investments to repair or modernize the infrastructure using bank loans. The irrigation fees serve as a guarantee to the banks. More than 90% of farmers paid their assessed charges, mainly because they have to pay the irrigation charges before receiving the WUA service. One of the major reasons for the positive Mexican experience is the commitment at the highest level of government. The success of WUAs is also enhanced by the skills of its hired technical staff. In many districts in Mexico, WUAs assist their members in commercializing their operations, obtaining inputs and renting machinery (Palacios, 1999).

A survey of two minor canals in Mula and Bhima, Maharashtra, India summarized the general benefits of WUAs. By comparing four districts, two with WUAs already in place and two without WUAs, Naik & Kalro (2000) found that in systems with WUAs, 75% of the farmers were willing to pay 25% higher water charges because of the better service they received. The major reasons for choosing WUAs were assurance of water delivery and supply, fewer disputes among farmers, better maintenance and no corruption.

System transparency is another key factor that has had a significant impact on farmers' willingness to pay their water charges. System transparency means that farmers can see how much water they received, how their payments are used and how water charges are determined. The IC machines in Shangdong, China, illustrate good system transparency in terms of water delivery and payments. Farmers interviewed said they were satisfied because they received an electronic printout indicating how much water was released, the water price per unit and the total amount they paid each time they use their IC card to release water. The case in Sindh Pakistan is a counter example. Farmers are not willing to pay because their financial system is not transparent and they do not see that the charges paid are used in their system owing to the corruption of irrigation officials. The farmers said that they were willing to pay for the services, but not for "someone's wife's jewelry" (Cornish & Perry, 2003). This report also suggests that when corruption is well embedded in an irrigation system, it may be very difficult to eliminate completely<sup>6</sup>.

In summary, **Table 2** illustrates where financial autonomy and user participation, combined with transparency, have been key factors in achieving high collection rates. A major task for management

<sup>6</sup> Rinaudo's study (2002) in Pakistan shows that corruption and bribery are deeply imbedded in their irrigation system and have even become part of the system. The study shows that not only economically and politically powerful farmers are involved in the corruption but also small landowners/farmers. The system of administrative corruption involves about one-quarter of the rural population in the studied irrigation system. Therefore, the author points out that it is very difficult to completely change since the "work rules" of the system are so well established. He suggests that improving the transparency of the functioning of the hydraulic system should help, i.e. for each irrigation system, reliable data on the discharge entering the main canal and its distribution canals should be collected and made available to all the water user federations (WUFs). He also argues that establishing an independent "control panel" would help improve system transparency.

Table 3. Factors influencing water use efficiency

Cases	Increase per unit price	Switch to volumetric metering	Pricing structure	Water-saving technology availability	Assurance of water delivery	Public awareness	Education Technical assistance		Source
Awati, China	Yes	Yes	Increasing block	N.A.	N.A.	Yes	N.A.	50 m <sup>3</sup> /mu	Awati County Government, 2002
Shangdong, China	N.A.	Yes	Volumetric	N.A.	Yes	N.A.	N.A.	5 Bm <sup>3</sup>	Wang & Lu, 1999
Yangtze Basin, China	No	Yes	Volumetric	N.A.	Yes	Yes	N.A.	1.18 Mm <sup>3</sup> in WUA	Lin, 2003
Katepurna, India	N.A.	Yes	Volumetric	Yes	Yes	Yes	Yes	7.71 Mm <sup>3</sup>	Belsare, 2001
Tunisia	Yes	Already used	Volumetric	Yes	N.A.	Yes	N.A.	N.A.	Hamdane, 2002
Mula area, Spain	N.A.	N.A.	N.A.	Yes	Yes	N.A.	Yes	101 Mm <sup>3</sup>	Garcia, 2000

N.A. = information not available; 1 mu = 0.067 hectare.

reforms is to create incentives so that farmers have an increased willingness to pay their water charges. Although in some groundwater irrigation systems, water charges required to cover O&M fully may be too high relative to net farm income, in most cases water charges are only a small share of farmers' net income, 2–7% (Easter & Liu, 2005). Thus, low collection rates appear to be caused mainly by a lack of willingness to pay rather than by inability to pay. Examples from China, India and Mexico illustrate what is possible if reforms are successful. These practices, combined with incentives for service providers and farmers, are critical for high cost-recovery rates. When the salaries of irrigation personnel depend on the collection of water charges or the prepayment of water fees is required, or both, collection rates are high.

### *Keys to reducing water use*

To encourage farmers to use less irrigation water per hectare, water charges need to be related to the amount of water that farmers receive. Thus volumetric water pricing should be considered when reducing water use per hectare is a major concern. In cases of high volumetric measurement costs, area-crop or area-technology based pricing methods can be considered as a second best approach if they can be designed to influence water use, as discussed above.

Table 3 provides a summary of irrigation systems and factors that help reduce water use per hectare. There are two general approaches for reducing water demand through pricing. One is to set the per unit price high enough so that farmers use less water on existing crops, which is essentially a movement along the demand curve. The second approach is to shift the entire demand curve by inducing farmers to change crops or irrigation technology, or both. A number of studies of individual crops suggest that irrigation water demand is quite inelastic, suggesting that movement along the demand curve will have only a limited impact on the quantity of water demanded<sup>7</sup>. In Tunisia, the price elasticity of water demand was estimated to range from  $-0.03$  in the northeast and  $-0.007$  in the center-west to  $-0.27$  in the northwest and  $-0.34$  in the south. The first two areas have very inelastic water demands because they produce high-value crops under controlled water conditions (fruit trees, vegetables, plastic-covered agriculture irrigated by modern technology) (Hamdane, 2002).

In a case in Iran, water prices would have to be raised from US\$4 per 1,000 m<sup>3</sup> to US\$20 per 1,000 m<sup>3</sup> to reduce demand significantly (Perry, 2001). This suggests that these farmers would need to have better alternative crops or technologies to be able to reduce water use per hectare. Therefore, an increase in per unit water price may not be an effective way to reduce demand if alternative crops and technologies are not readily available and water price elasticity of demand are low. Yet Schoengold *et al.* (2004) found own-price elasticity of agricultural water demand ranging from  $-0.275$  to  $-0.415$  in California's San Joaquin Valley. They found that indirect effects account for only 17% of the change in water use. In other words, just reducing water use on the existing crops was more important than changing to water-conserving crops or to improved technology. Their study suggests that movements along the demand curve produce significant water savings. However, where water demand is fairly inelastic, policies and

<sup>7</sup> An inelastic demand curve has a steep slope where the responding percentage change in quantities demanded is smaller than the percentage price change. Demand elasticity =  $\% \Delta Q / \% \Delta P$  (percentage change in quantity relative to percentage change in price).

practices that shift the demand curve down and to the left (reducing water use) will be needed, as discussed below.

### *Supporting institutions*

If there is a wide variety of crops to choose from, policymakers can use either area-crop-based pricing or increase the per unit volumetric price to induce a shift to crops that use less water. The same strategy can be applied to induce an irrigation technology shift. The pricing mechanism can be either volumetric or area-technology-based. The price increase will be even more effective if combined with other policy interventions such as providing positive support or taking back subsidies that encourage lavish water use. Low-interest loans for new irrigation equipment and technical assistance will help encourage farmers to adopt appropriate water-saving technology. In Gujarat, India, electricity used by tube wells is charged at a fixed rate per month and is heavily subsidized (Cornish & Perry, 2003). Therefore, electricity charges do not include any charge for the marginal cost of pumping groundwater. In this case, the government should eliminate the electricity subsidies, which have been encouraging overuse of groundwater and charge for electricity based on the amount of electricity used. The resulting increase in pumping costs would encourage farmers to pump less groundwater.

### *Quotas*

Besides using pricing tools, quotas can be used to reduce water demand (Morris *et al.*, 1997). When water users are not responsive to water price changes, a quota can be effective in reducing water consumption by creating a high shadow price. The implementation costs of quota systems can be high because the quantity of water that goes to each farm must be controlled. There are different ways of implementing a quota system. First, a quota system for groundwater pumping can be devised by establishing a specified annual rate of extraction from each well in proportion to the recharge rate, combined with a limit on the installation of new wells. A second approach would be a fixed allocation of water shares to different canals or water users sharing the same canal. The fixed shares or quotas could also be allocated to WUAs (Tiware & Dinar, 2003). For example, in Maharashtra, India, the WUA receives 0.77, 0.86 and 0.62 million cubic meters of water during winter, dry and summer seasons, respectively and they can also draw on any unused water quota from the previous season in the current season (Naik & Kalro, 2000).

### *Service contracts*

Another way of reducing water use per hectare is to provide farmers with assurances regarding water deliveries through formal or informal service contracts that specify water delivery times and quantities. If this is done, farmers will not have an incentive to store water on their field by over-irrigating. Since system reform in Katepurna, India, farmers stopped over-irrigating because irrigation scheduling is planned and announced before the crop season, based on water requirements and soil type. Farmers do



Table 4. Country conditions and irrigation practices

Country conditions and policies	Good practices	Good practices				Management transfer	
		Pricing structure and/or technology that encourages water savings	Assurance and transparency in water delivery	Public education/ technical assistance	Water market	Financial autonomy	User participation
Physical conditions	Water scarcity and drought common	Awati, China; Katepurna, India; Tunisia	Shangdong, China	Tunisia	N.A.	Gujarat, India Mexico	Gujarat, India
	Infrastructure in poor condition	Mula, Spain	Katepurna, India; Mula, Spain	Katepurna, India Mula, Spain	N.A.	Mexico	Katepurna, India
Economic/ political conditions and policies	Economic liberalization	Yangtze, China	Yangtze, China	N.A.	Elqui, Limari and Maipo rivers in Chile	Awati, Bayi, Nanyao, Yangtze, China; Mexico	Indonesia; Mexico
	Decentralization	Shangdong, China	Shangdong, China	Yangtze, China, Alto Rio Lerma, Mexico	Murray and Darling rivers in Australia	Awati, China; Gujarat, India; Mexico; Sri Lanka	Bayi, Nanyao, Yangtze, China; Mexico; Sri Lanka; Indonesia
	Serious financial constraints	N.A.	N.A.	N.A.	N.A.	Bayi, Nanyao, Awati, China; Mexico	Bayi, Nanyao, Awati, China; Mexico
Legal/ institutional arrangements	Definition of water rights	N.A.	Haryana, India	N.A.	Siurana-Riu decanyes, Spain; Cariri, Brazil	Mexico	Haryana, India
	Effective local system for enforcing water use rules	N.A.	Bayi, Nanyao, China; Haryana, India	N.A.	Siurana-Riu decanyes, Spain	N.A.	Alto Rio Lerma ID, Mexico
	Rights to establish WUAs	Awati, China	Bayi, Nanyao, China;	Bayi, Nanyao, Awati, China	Northern Colorado, USA	Mexico	N.A.

N.A. = information not available.

not have to irrigate in the monsoon season just so that they will have adequate soil moisture for the dry season crop. Farmers now have an adequate and timely water supply, which has resulted in reduced water use per hectare. Not only do they save 7.7 million m<sup>3</sup> of water annually but they have also expanded the irrigated area from 2,027 ha to 3,646 ha. This case shows a real increase in productivity (Belsare, 2001). In Shangdong, China, the implementation of IC automatic machines gave farmers full control over water use. They were able to obtain the right amount of water when they wanted it. The end result is a 5 billion cubic meters saving of irrigation water in the province annually (Wang & Lu, 1999).

### *Education*

Public education campaigns can also be an effective mechanism to increase farmers' awareness of the real scarcity value of water and to help persuade them to conserve water. This is especially important in places where people traditionally view water as a free good and a basic right. In many projects, public education programs, combined with price increases, have been effective. In Katepurna, India, efficient water utilization was promoted through newspapers, radio, exhibitions, pamphlets and posters. Slogans on participatory irrigation management and efficient water use were written on compound walls, canal structures, offices and public buildings. To motivate irrigators, cultural groups were formed from department staff members and cultural programs (e.g. songs, drama) were arranged at the village level (Belsare, 2001). This helped motivate irrigators by improving the community's understanding of the value and importance of irrigation water.

### *Non-price incentives*

Other non-price incentives can be used to induce water conservation. In some irrigation projects, conveyance loss is more than 40% of the total amount of water delivered. The most effective incentive for inducing service providers to reduce these losses is financial autonomy. If the service providers are completely responsible for the water project and fee collection, they will try to reduce water losses so that they have more water to sell, as happened in the Yangtze Basin, China. Table 3 provides other examples of how a combination of different incentives can be used to reduce water demand even when the water demand for one crop, with a given technology, is inelastic. The critical issue is that, when the major objective is to reduce water use, a combination of incentives should be used, not just higher water prices. Even when water cannot be metered effectively, other actions can be taken to help reduce water use, including crop-based water fees.

### **Conclusions**

There is no one easy means to improve cost recovery. However, many countries have greatly improved cost recovery through basic irrigation reforms. The reforms varied with the type and physical condition of the irrigation system, management structure, government policies, political and economic conditions and institutional arrangements (Table 4). Giving farmers more authority

and responsibility over water management, usually through WUAs, is a part of most reforms. In some cases, reform will require other investments or improvements in water management. In Sri Lanka, for example, besides creating WUAs, infrastructure investments were also needed to improve system productivity (Samad & Vermillion, 1998). A transparent process, where farmers help decide what components should be included in the costs to be recovered through user charges, is an important stepping stone toward increasing their authority. To obtain high cost-recovery rates, farmers also need to see that the fees collected are used to maintain and improve “their” irrigation system. Having the fees collected go back into the general revenue fund of the state or federal government, provides farmers with a strong incentive not to pay fees. As part of widening farmers’ responsibilities and authority over water management, the government should provide them with training and technical assistance, as was done in a number of the successful cases (e.g. the Yangtze Basin Water Project in China). More should be done to reduce and prevent corruption in water distribution and fee collection. In many cases, the “rents” extracted from farmers by irrigation officials are so large (sometimes 10 to 20 times their normal salary) that raising or introducing official water charges (in addition to the “informal” charges) can be very difficult.

Another effective tool for improving cost recovery and pricing is to make the irrigation water supply entity (WSE) financially autonomous, similar to the water supply corporation created at the Tieshan Irrigation District in the Yangtze Basin, China. Making the WSE financially autonomous changes the incentives for cost recovery and pricing. If the WSEs are financially autonomous, they have a financial stake in using incentives and penalties to encourage farmers to pay their water charges. These WSEs also have a financial stake in providing their personnel with a positive incentive to deliver water on time and in the right amount, as well as a penalty if they do not. To increase its effectiveness, the water supply entity needs to consult directly with farmers when they are developing the water delivery schedule for the next irrigation season, as is done in the Katepura project in India. After the schedule is developed, it, plus any future charges, should be widely advertised along with a statement regarding the water charge farmers are expected to pay. The WSE will also have a strong incentive to invest in improved infrastructure to bolster their control over water delivery and reduce water losses. The improved water control will allow them to provide better services as well as better measures of water delivered.

The fee structures have to be equitable, administratively simple and easily understood by users and those administering the fee collection. Part of this involves identifying the full range of services and benefits produced by the project and allocating project costs among all beneficiaries. In addition, information on the costs of services and benefits derived from the project and on the way project costs are allocated among beneficiaries should be provided for all users. For a new project or any major improvement in infrastructure, users’ ability and willingness to pay should be assessed.

As water scarcity increases, more irrigation projects will have to take seriously the water conservation objective and begin using water pricing and other mechanisms to encourage water conservation. When water metering and volumetric pricing are not possible, area-crop and area-technology-based water charges should be designed to strengthen farmers’ incentives to shift to crops that need less water, or to shift to water-saving technologies, or both. Subsidies can also be used to encourage the adoption of water-saving technologies. Where feasible, water markets should be encouraged as a means of improving water allocation as well as water conservation. Public awareness, education and training programs should be used in water-scarce regions to make farmers fully aware of the economic value of water and the need to use it judiciously. Technical assistance is another way to help farmers switch to

better irrigation cropping practices and technologies. Finally, when irrigation is being introduced for the first time, special farmer training programs should be implemented well before the irrigation water is made available.

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