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# Cost Recovery and Water Pricing for Irrigation and Drainage Projects

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# EXECUTIVE SUMMARY

Water pricing[1] and recovery of the costs of irrigation investment, operation, and maintenance have been contentious issues for many decades. The low charges for irrigation water are questioned, as well as, the small percentage of farmers who actually pay the charges. In some projects, fee collection rates are near zero, even when water charges are well below the cost of project operation and maintenance (O&M) (Ahmand 2002; Easter 1993; Govt. of People's Republic of Bangladesh 2000; Svendsen et al. 1997). This creates serious problems both for irrigation agencies and, in the long run, for farmers. If the fees collected do not cover the costs of an irrigation project, its sustainability, without continued government subsidies, may be at risk.

Water fees are collected from farmers for two main reasons. The first is to cover the O&M cost so that the project is financially sustainable. In many cases, fees will also need to include a charge for the cost of capital required to construct the project. This charge for capital is important for future irrigation investments. The second objective involves pricing to encourage farmers to use less water per unit of output or produce greater net economic returns per unit of water, or both. Historically, the first objective has been paramount, but as water scarcity increases, the water use efficiency objective is likely to grow in importance and be given a higher priority. Efficiency is used in the economic sense: maximizing benefits subject to technical and physical limitations (Prato 1998). Efficiency in water use means maximizing society's benefits over time from the water and technology available. In practical terms, improving water use efficiency means increasing the value of crop output per unit of water consumed through evapotranspiration (ET) by plants.

To illustrate the problem, consider several countries that have historically had a poor record of collecting water fees. In 1984, collection rates of assessed water fees were only 20 percent and 8 percent, respectively, in Nepal and Sri Lanka, while it was 38 percent in Turkey in 1989–94 (Easter 1993). In his 1995 study, Jones rated cost recovery in 105 of the World Bank's 208 irrigation projects and found 68 percent unsatisfactory and only 32 percent satisfactory (see Table 1 for further examples). Considering this poor record, it is not surprising that the World Bank and others have been trying to identify the reasons for these low collection rates and ways to improve them.

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 of 20 World Bank staff members with responsibility for irrigation sector reforms in countries from Asia to Latin America (names listed in Appendix 1). From these studies and interviews, we distilled specific reforms that are important in improving cost recovery or reducing water use, or both. Reforms needed by individual countries or projects will depend on their institutional arrangements as well as the type of irrigation and its physical condition.

The second section of the paper begins by listing some reasons for low collections and provides

an overview of some of the reforms that have raised collection rates. In the next section, we review cost-recovery principles and provide some examples of what different countries have done to recover project costs and collect water charges from users. The focus in the fourth section is on designing water charges or water markets that will give farmers an incentive to make better use of their water by reducing the amount of water used per unit of output. In the fifth section, we use case studies to determine what reforms can help improve cost recovery and increase collection rates. In addition, water pricing reforms are identified that will encourage farmers to reduce their water use per unit of output. The final section provides a summary of the reforms that are important for increasing cost recovery and encouraging farmers to improve their use of water.

# 1. WHY COST-RECOVERY RATES ARE LOW

In developing countries as well as in many developed countries, there are many different reasons for low water fee collection rates including the following:

- No link between fees collected and funds allocated to an irrigation project
- Lack of farmer participation in project planning and management
- Poor communication and lack of transparency between farmers and irrigation management
- Poor water delivery service (timing, duration, or quantity inadequate) and no penalties for managers and irrigation project personnel who provide poor service
- No user penalties for nonpayment of water charges
- Low priority given to fee collection, efficient water use, and system O&M
- Small size and very low incomes of irrigated farms
- Corruption of irrigation officials.

The list illustrates that the cost-recovery problem is, at least partly, an assurance problem: assurance regarding what water users will do, as well as assurance concerning what water managers and their staff will actually do as opposed to what they say they will do (Easter 1993).

**Table 1. Selected Countries Or Regions Reporting Low Cost-Recovery Rates Or Low Collection Rates**

| *Country/region* | *Collection rate* | *Percentage of cost recovered* | *Comments* |
|---|---|---|---|
| Argentina 1997 (Svendsen et al. 1997) | 70 percent | 12 percent of O&M | Water charges are very low and based on area: fixed area fee of $70/ha/year. Fee collections are managed jointly by the government and the water user associations. |
| Bangladesh 1998 (Government of People's Republic of Bagladesh 2000) | 3 to 10 percent | Low | In 1997–98, water charges were levied in only 6 of the 15 major irrigation schemes. |
| Botswana 1994–95 (Thema 1997) | n.a. | 44 percent of the O&M in 1995; cost-recovery rates have been between 35 and45 percent since 1988. Government pays capital cost | Increasing block pricing system. By the end of 1996–97, revenue was scheduled to recover O&M costs, but by 1995 charges were too low to cover these costs. |
| Jaiba Project , Brazil 1995 (Azevedo 1997) | 66 percent | 52 percent of total costs | The two-part water charging system is well designed, but collection rates are too low. |
| Columbia 1996 (Svendsen et al. 1997) | 76 percent | 52 percent of O&M | Responsibility for fee collection has been shifted to water user associations. The transfer was too quick, with too little time and effort invested in clarifying water users' rights and responsibilities. |
| Maharashtra, India 1984 (Easter 1997) | 58 to 67 percent | n.a. | There is no link between fees and funds allocated for O&M. There are penalties for default payments, but neither user participation nor incentives for service providers to collect fees. |
| Italy 1997 (Destro 1997) | n.a. | 60 percent of total costs | Water charges are too low and based on area. |
| Jordan 1999 (Rupert and Urban 1999) | n.a. | 50 percent of O&M | Water fees are too low, services are not related to water charges, meters are broken, and the volume of water used is deduced from an assumed discharge rate instead of using the meters. |
| Macedonia 2000 (Hatzius 2000) | 42 percent | n.a. | There are no incentives for service providers to collect fees, and user penalties are not effectively enforced for nonpayment. |
| Nepal 1984 (Easter 1993) | 20 percent | n.a. | There is no link between water fees and O&M. Fee collection is not given high priority. There are no incentives to collect fees and no |

| *Country/region* | *Collection rate* | *Percentage of cost recovered* | *Comments* |
|---|---|---|---|
| | | | enforcement of penalties for nonpayment. |
| Pakistan 2001 (Ahmad 2002) | 30 to 35 percent | n.a. | Revenue from water charges is pooled with other taxes and goes to provincial treasury. There is no clear link between fee payment and service provided. |
| Philippine 1995 (Svendsen et al. 1997) | 58 percent | 46 percent of O&M | Area-crop–based water charges, US$77/year/ ha on average in 1997. |
| Sri Lanka 1984 (Easter 1993) | 8 percent | n.a. | Communication between farmers and irrigation officials is poor. There is no clear responsibility for O&M. |
| Tunisia 1991 (Hamdane 2002) | n.a. | National average is 70 percent of O&M costs; ranging from 44 percent in the Central region to 76 percent in the Northern region. | Water charges are too low and the public agency managing irrigation is not financially autonomous. |
| Turkey (Dinar and Mody 2004) | 76 percent (1998) | 32 percent in 1991<br>37 percent in 1998, and 50 percent in 1985, the highest rate, | Two-part pricing system. O&M fees are area-crop–based. Capital cost recovery is low and does not start until 10 years after project completion. There is no inflation adjustment despite a 70 percent high inflation rate. |

Note: O&M = operation and maintenance

Source: listed in table by country/region

The main reasons for low cost-recovery rates are likely to vary among countries and even among projects within one country. The good news is that steps can be, and have been, taken to correct some of these problems. For example, more and more countries have started to encourage water user participation by establishing water user associations (WUAs). In many cases, system management turned over to farmers. Both Turkey and Sri Lanka have used management turnover as a means of improving performance. For Turkey, it helped increase cost recovery to 76 percent in 1998 (Table 1). Sri Lanka did not experience any significant improvement in productivity with turnover, however, except where it was combined with project rehabilitation (Samad and Vermillion 1998). In addition, there is no direct cost-recovery system in Sri Lanka. Instead, the government feels that it gets indirect cost recovery by transferring management to farmer organizations that have full responsibility for O&M below the head of the distributional canals[2].

Other steps taken to improve cost recovery include improved irrigation service and more transparent decisionmaking. The success of these steps depends on government policies as well as institutional arrangements including the basic legal system. The emphasis should be on getting farmers to accept the idea that they should pay for irrigation water and agree on what the cost should include. Farmers will not want to pay if service is poor and the fees paid bear no relation to system O&M. Incentives are also needed to encourage better service delivery and raise farmers' willingness to pay. For many countries, a combination of actions will be needed, as illustrated by the World Bank–supported Yangtze Basin Water Resource project (Lin 2003).

The goal of the Yangtze reform was to establish a self-financing and self-managed system consisting of two integrated parts: the water supply corporation (WSC) supplying water from the headworks and the water user associations operating at the local level. Farmers at a water users' conference elected a WUA executive committee. Villages helped mobilize community human resources for both the WUA conference and the executive committee election, which helped improve farmer participation and WUA operations. The WSC charter also requires farmer representatives from the WUAs to be on the WSC board of directors, so that farmers are directly involved in WSC management and decisionmaking. Irrigation project authorities and local water bureaus constantly held training programs for farmers, which helped enhance the WUAs' operational capacities after transfer of the local irrigation systems. As a result, farmers are actively trying to improve their system through strong user participation, although in some areas village leaders have tended to dominate associations (see Box 1).

**Box 1. Yangtze Basin Water Resource Project: Self-Financing Irrigation And Drainage Districts In China**

Control of local irrigation by water user associations (WUAs) has saved both water and labor, as well as shortening the irrigation time cycle. Water is now delivered on time and in the right amounts. This increased availability of irrigation water has reduced farmers' incentives to steal water. WUAs improved system maintenance in both the main canal and the lower distribution network. Farmers are investing labor and funds in the projects, because they now view them as their own. Irrigation costs have been reduced in multiple ways since the introduction of WUAs and volumetric pricing. Farmers are using less water per hectare, and delivery losses have dropped. On average, each WUA has saved about 1.18 million $m^3$ of water annually, and productivity has improved. After introducing the WUAs, the average crop yield increased by 6 percent, of which 2.5 percent was purely due to irrigation improvements. Improved delivery of irrigation service has also helped reduce poverty. In WUA areas, even poor farmers are now able to secure their harvest regardless of the weather.

However, Zhang et al. (2003) have pointed out some problems concerning the representation of users in some WUAs and decisionmaking.

First, in terms of user participation, farmers are largely involved in construction and maintenance of irrigation

infrastructure, but not in the decisionmaking process of water allocation. Also, there are no checks and control mechanisms among the WUAs. The majority of participants in the WUA elections are village officials instead of ordinary farmers. In most places, village officials are still responsible for collecting water charges. About 80 percent of the farmers sampled think that WUAs, not village officials, should have the legal right to collect fees, because some village officials divert water fees for other purposes. WUAs finances are not transparent to most farmers. Finally, few farmers understand the basic WUAs concepts. They still think the WUA is just an extension of government and do not feel it is their own organization.

Source: Lin 2003.

# 2. COST-RECOVERY PRINCIPLES

Improving cost recovery clearly involves more than just charging higher fees or spending more on fee collection. However, which water costs are to be recovered and what mechanisms can be used to recover them have to be specified. The full costs of providing irrigation water can be divided into three categories: direct project costs, environmental costs, and marginal user costs. Direct project costs are the easiest of the three to measure, and most projects take only direct costs into account in determining cost recovery. Direct costs refer to costs stemming from the process of capturing and delivering irrigation water, which can be broken into fixed costs and variable costs. Fixed costs include all investments in irrigation infrastructures such as building reservoirs and canals and installing meters and pumps, plus depreciation and interest payment on the investment. Higher level administrative costs and some operational and maintenance costs not involved with actual water delivery are also considered fixed costs because they do not vary with the amount of water delivered. Variable costs consist of the operational and maintenance costs of water delivery, lower level administrative costs (usually temporary labor costs during the time of water delivery), and costs of supplying water, which include conveyance costs, groundwater extraction costs, and costs due to water loss. 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 waterlogging and salinity problems caused by the irrigation. However, few irrigation projects in practice include environmental costs as part of their full cost to be recovered. 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 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 and MacDonald 2004). However, in Queensland, when the government reviewed water resource charges in 2004, most communities rejected the idea of introducing an externality charge. They argued that many water users already provide infrastructure to mitigate externalities, and that further improvement should be achieved through regulatory planning (Queensland Government 2004).

Marginal user cost is defined as the present value of future sacrifices implied 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 relevant for groundwater resources with little or no recharge. Excluding marginal user costs in the price of groundwater often results in overuse of the resource.

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 number of beneficiary groups besides irrigated farmers. Irrigation projects serve multiple beneficiaries in two major ways. One case is multipurpose projects; the other is projects involving indirect beneficiaries of the increased agricultural production.

Multipurpose water projects are common. Besides supplying irrigation water, projects may also supply water for household and industrial uses as well as providing flood control and hydropower. In Asia, 90 percent of dams for irrigation are multipurpose. In these cases, different users should share the costs in proportion to the services they receive. There are three common methods for allocating costs among users: the use of facilities (UOF), alternative justifiable expenditures (AJE) and Separate Costs, Remaining Benefits (SCRB) methods (Easter 2003; Young et al. 1982; Young 1985). 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) and exclude the costs of a change in project design due to the inclusion of a particular purpose. AJE easier to calculate than SCRB because it relies on specific[3]costs rather than separable[4] costs. The third approach, SCRB, is similar to the second one. 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 Andhra Pradesh, India, provides a good example of how the costs from a multipurpose water project can be allocated among different types of uses or purposes (see Box 2).

In projects with large indirect benefits, some of the costs may be allocated to the 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, subsidizing the project through tax revenue from the benefiting consumers and processors might be an alternative to help fund the project.

**Box 2. Alternative Cost Allocation In Three Projects In India**

Two alternative cost allocations were calculated for the distribution of project costs. The first allocation is based on the quantity of water delivery for each purpose or use. Since the allocation is based on water delivery, only the three consumptive uses are allocated a share of the costs, with between 95 and 98 percent of the cost allocated to irrigation (Table A). When the costs are allocated based on benefits generated, all five major water uses are allocated costs, and irrigation's share drops to between 88 and 94 percent (Table B). Thus, in multipurpose projects, irrigation is likely to be allocated a major share of the costs but, with growing domestic and industrial demand for water, irrigation's share is likely to drop significantly over time. In projects that include an important flood control component, irrigation's cost-share would drop even more.

**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 |

**Cost Allocation Among Three Projects Based on Benefits**

| | *Three Water Projects* | | |
|---|---|---|---|
| *Purpose or use* | *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.

The Sana'a basin water management project in Yemen illustrates the idea of government cost sharing where a major objective of the irrigation improvement program is to reduce the rate of groundwater exploitation. The strategy is to reduce the speed of groundwater mining and extend the useful life of the aquifers to gain time for the government to find long-term solutions. Examples of such solutions might be to shift the focus of the basin's economy to less water-intensive activities and to encourage out-migration from areas with groundwater mining. In the short run, farm-level water conservation practices are being subsidized in areas irrigated by groundwater. For example, the government introduced piped conveyance and distribution systems, as well as drip and bubbler technology, in the pilot areas. Irrigation efficiency was improved from 35 percent to 60 percent. The government is responsible for 75 percent of the investment costs and 90 percent of the installation costs; farmers are responsible for the rest of the costs. Farmers also pay 100 percent 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). Senior Water Resource Management Specialist M.F. Abu-Taleb of the World Bank (co-task team leader on the project) reported that WUA involvement in the implementation of the irrigation project was overwhelmingly positive. Users have signed up to pay for and install the subsidized water conservation equipment in the pilot phase.

# 3. PRICING SCHEME DESIGN

To achieve the two primary goals of cost recovery and reduced water use per unit of output in irrigation water management, two key issues must be addressed: first, to design an effective pricing mechanism based on local conditions and, second, to develop a strategy for obtaining high rates of collection.

In this section, we focus on the three major methods for pricing water: area-based pricing, volumetric pricing, and market equilibrium pricing. Emphasis is placed on the first two categories, including extensions, modifications, and combinations of the two.

### AREA-BASED PRICING

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. Defining O&M costs is important because the water supply entity may have an incentive to inflate the costs charged to farmers. In addition, the use of irrigated area varies from year to year and season to season. For example, the area irrigated during the wet season is usually much larger than during the dry season. In addition, the project area is usually larger than the area actually irrigated. Therefore, irrigation officials will need to estimate the area actually irrigated each season.

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 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 it is likely to lead to overuse of water by farmers near the head of the canal.

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. Also, assuming 100 percent collection rates, charges per hectare, based on average direct cost, result in full recovery of direct costs. Although it gives farmers no incentive to reduce water use per hectare, it is still widely used in many systems throughout the world due to the simplicity of its implementation. In Haryana, India, irrigation water is priced at US$2.50 /ha[5] (Cornish and Perry 2003), while in Pakistan, prices range from $2 to $8/ha but are set to cover only part of the O&M costs (Ahmad 2002).

Pure area-based pricing is 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 pricing systems are becoming less and less popular, and most of the recently designed area-based pricing systems are adopting new features. The extensions of area pricing include area-crop (the most widely used modification), area-irrigation, area-season, and area-technology–based pricing.

Area-crop–based pricing systems vary the charge per hectare irrigated by type of crop. The water price variation among crops depends on the policymakers' objectives. If they want to encourage efficient use of water, the high water-consuming crops such as rice, should have higher prices per hectare. If the price differences are large enough, farmers are likely to switch to alternative crops. Box 3 gives examples of how area-crop–based pricing can induce crop changes that save water. In contrast, if the government is pursuing a low food price policy or wants to encourage production of commercial crops, the water price for these crops could be set lower than for other crops. However, care must be taken in subsidizing inputs such as water to increase crop production because it often leads to inefficiencies and

overuse of the resource, particularly with crops such as rice and sugarcane.

**Box 3. The Area-Crop-Based Pricing And Its Impact In India And Egypt**

*Haryana, India: An Empirical Illustration of The Performance of Different Water Pricing Methods*

A numerical example using data from Haryana, India, illustrates the impacts of two different pricing methods. Farmers can choose to grow cotton or wheat; cotton is more profitable but uses more water than wheat. Two pricing methods are considered: area-crop–based pricing, with a higher price for irrigating cotton, and volumetric pricing. For area-crop–based pricing, the implementation cost is low, but high for volumetric pricing. An area-crop-based water charge of $231/ha for cotton and nothing for wheat induces the farmers to switch from cotton to wheat. Farmers' profit decreases by one fourth, but the social benefit increases almost sevenfold. This example illustrates how a simple method, area-crop–based pricing, can be more effective than an efficient but complicated volumetric pricing, when implementation costs are high. The implementation costs include both the fixed costs of installing meters and the added variable costs required for water delivery and monitoring.

*Egypt. The Impact of Different Pricing Methods on Irrigation Water Consumption and Farm Income*

Several studies in 1995 by International Irrigation Management Institute (IIMI) measured the impact of different pricing alternatives on the agricultural sector in terms of irrigation water used and farm income. Three pricing schemes were tried. First, a fixed rate of $52 per hectare, irrespective of crop or water use, resulted in a fall in farm income of 4.5 percent but had no effect on the choice of crop or technology. Second, an area-crop–based charge, proportional to the calculated average water consumption of each specific crop, resulted in a 2.4 percent fall in farm income. The demand for irrigation was water reduced by 3.5 percent and the returns to water increased by 2.7 percent. Third, a volumetric charge based on the quantity of water delivered resulted in virtually identical impacts as those obtained in the second case. The key factor explaining the different responses appears to be the availability of a range of crops that farmers can choose to grow.

Sources: India, Tsur and Dinar (1998); Egypt, Perry (1995).

In the area-irrigation method, water charges usually reflect the differences in water delivery costs among different irrigation methods. For example, most gravity-based irrigation systems have much lower variable costs than pump irrigation. The advantage of pump irrigation is that water control and measurement of water delivery is generally much easier than it is for most gravity flow systems. Thus, area charges are usually higher for pump irrigation because irrigation costs and net income per unit of water are generally higher.

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 was 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. The long-run marginal cost is usually the cost of future expansion. In reality, it is often difficult to estimate the cost of the next big supply-capacity-expansion project (McNeill and Tate 1991). During the off-peak seasons, France includes only operating costs. This pricing structure has helped reduce water use during summer when demand is high compared to supply (Tiwari and Dinar 2003; Johansson et al. 2002).

Another possible combination is area-technology–based pricing. Although it has not received much attention, theoretically it should 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. Therefore, a higher per hectare fee could be

levied on farmers not using these technologies to encourage them to switch.

If area-based charges can be established that reflect differences in water use by season, crop, or irrigation technology, area pricing would have some of the benefits of volumetric pricing. This would be the case if, after controlling for crop, irrigation technology, and season, there was little variation in water uses per hectare. Problems are still likely to exist because farmers at the head of the canal tend to overirrigate their fields when water charges are based on area. However, if farmers can be assured that each scheduled water delivery will be on time and in the quantity demanded, they will have much less incentive to overirrigate than with irregular deliveries. These and other incentives will be discussed in more detail below, when guidelines for implementing effective water pricing are considered.

## 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 delivered to your farm. However, it has several disadvantages. First, the implementation costs can be high because meters are 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., 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 overcollection as well as high water charges relative to farm income. For example, in a deep tubewell project in Gujarat India, the water fee is 37 percent of net farm income and does not cover O&M costs because electricity is heavily subsidized. In contrast, for gravity-based systems the water fee is usually a much smaller percentage of net farm income (see Table 2). To address the concerns about the impacts of water charges on farm income, two different modified versions of volumetric pricing can be used.

### Block pricing

Block pricing involves varying the water price when water use for a set time period exceeds a set volume (e.g. 5,000 $m^3$ per hectare per season). If high water charges are a concern, an increasing block charge can be used. The price of the first block can be set below O&M costs. The second and later blocks are raised to higher rates that cover O&M costs and reflect the marginal cost of operations. Israel (Yaron 1997) and Botswana (Thema 1997) both use this pricing method. The amount of the first block is often considered the basic amount of water needed to support a farm family, so this method also attempts 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. In Botswana, the price of the second block is twice the price of 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 still obtain additional water by paying irrigation officials or private sources a high enough price. Both Botswana and Awati in China call their first block a “quota” and state that farmers have to pay double the price if their consumption exceeds the quota. In Israel, the quota includes three blocks, and charges are agreed to in signed contracts with the water provider[6].

If the price difference between blocks is large enough, farmers will try not to use more than the first

block of water. The disadvantage of block pricing is that it is not easy to decide the price level for each block or the quantity range of each block (e.g., should the low price apply to the first 5,000 $m^3$ used per season per hectare or the first 6,000 $m^3$). In addition, the revenue is unlikely to cover the O&M costs, particularly if the range for the first block is large. It is appropriate to use in cases where water is scarce, farm incomes are low, and water charges are high relative to net farm income (see Table 2). The advantage of the two-block pricing is that you have, at least, three instruments for influencing water use and cost recovery: the first and second block prices and the quantity (e.g., 4,000$m^3$/ha. vs. 5,000$m^3$/ha.) at which to start the second block price.

**Two-part tariff**

The second modification is a two-part charge, 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 less water use, 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 that does not depend on the amount of water delivered, and these fixed costs have to be paid even when water is not used for one season. The disadvantage is that it is relatively hard to calculate and difficult for farmers to understand. In addition, the administrative costs of a block-pricing scheme are likely to be somewhat higher than a single charge scheme.

**Table 2. Cost Recovery And Ability To Pay**

| *Case* | *Water fee as percent of net income* | *Water source* | *Collection rate and cost recovery* |
|---|---|---|---|
| Gujarat, India | 37 | Deep tubewell | No serious payment default problems, but electricity is heavily subsidized. The charge for electricity is far below the full cost-recovery level. |
| Haryana, India | 0.5 | Dams | High collection rate (90 percent or more). The irrigation department is able to achieve full O&M costs recovery by allocating only 33 percent of the overall costs to irrigation and charging a very low price (less than one-twentieth the costs to industrial, municipal, and other users). Even if the allocation was based on the proportion of water delivered, fees would be only about 2 percent of net farm income. |
| Haouz, Morocco | 7 | Dam | The collection rates are between 60 and 70 percent. Because it is a relatively new project, the O&M costs are as low as $30/ha/yr, but the full cost including capital repayment and depreciation is $54/ha/yr., almost double the O&M. Project-level data indicate that subsidies are substantial because, on the extensive "traditional" area, users do not pay the charge. In other areas, to reduce their payments to 40 percent of the designated charge, many farmers contribute their labor for cleaning the canals. |
| Tadla, Morocco | 15 | Dam | The collection rates are between 70 and 80 percent. Because this is Morocco's first and oldest irrigation project, its O&M costs are much higher than in Haouz ($127/ha/yr), and the full costs are ($150/ha/yr). Official statistics indicate that total collections exceed the O&M costs. |
| Sindh, Pakistan | 2 | Three barrages | The collection rates are poor, less than 30 percent of billings. Even at 100 percent collection rates, the current charge is still too low to cover the O&M costs. An assessment of ability to pay O&M costs was made in 1995. The result suggested that, despite the relatively low net farm income, farmers can pay for irrigation services. The collection rates are low because farmers are unwilling to pay due to corruption among irrigation officials and discontent over service quality and system transparency. |

Note: O&M = operation and maintenance.

Source: Cornish and Perry 2003; Ahmad 2002. For more information about those cases, see Appendix 2.

In the Jaiba project in Brazil, the pricing scheme is a revised two-part charge, consisting of two components, K1 and K2. The first component, K1, reflecting the project's capital cost, is calculated based on a 50-year repayment period and a subsidized interest rate. The second component, K2, is supposed to cover all the O&M costs and is estimated as a function of the volume of water used. The second component is further divided into two components: one representing the fixed O&M costs and the other, the variable costs. Farmers choosing not to grow crops for one season are still responsible for the fixed O&M costs (Azevedo 1997).

Besides the above pricing methods, Johansson et al. (2002) also suggest using output-based pricing methods. They also summarized many case studies from around the world, using different pricing methods to allocate irrigation water.

## WATER MARKETS

In countries with water markets, formal or informal, companies or individuals, can trade water at a

particular market equilibrium price that will likely 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 a judicial body to oversee trading activities and resolve disputes. They also require a well-developed conveyance system for transporting water to all participants (Tsur and Dinar 1998). If these requirements are in place, market equilibrium prices will effectively adjust supply and demand.

In Chile, analysis in two river valleys shows that water markets produced substantial economic gains from trade (Hearne and Easter 1995). The water market that has been operating in the Northern Colorado Water Conservatory district since the late 1950s is another example. The Northern Colorado Water district maintains a bulletin board where potential buyers and sellers post offers (Howe 1997). There has been a market in both permanent water rights and temporary sales just for seasonal water use. Over time, the permanent rights have gradually gone from agricultural to municipal and industrial use. However, agriculture is still by far the major water user (Kemper and Simpson 1999).

Localized markets have developed in a number of different settings in other parts of the world. The water market in Siurana-Riudecanyes irrigation district in the Tarragone province, Spain, is a classic example and is somewhat similar to the water market in Alicante, Spain (Maass and Anderson 1978). The Siurana-Riudecanyes system serves farmers as well as municipal and other users and delivers about 6 million $m^3$ of water annually. Water use rights, both long-term and temporary, are traded among WUA members, which include both farmers and municipal users. In 1982, an official exchange administered by the WUA was formed, which significantly reduced the volatility of water prices and made the exchanges much more transparent. A system of bonuses and incentives was also established for WUA employees to minimize water losses and reduce O&M costs.

The city council of Reus, the major city in the Siurana-Riudecanyes irrigation district, has played a significant role both in the water market and in the original construction of the water system. The city provided a large part of the funds to construct the dams and infrastructure. It financed 50 percent directly and another 40 percent with a loan to be repaid by the beneficiaries. The direct beneficiaries provided the remaining 10 percent of the construction funding upfront. Yet, it is the WUA that is the central focus of the water system, with active user participation, transparency, and water trading providing the flexibility needed to respond to changing water and economic conditions (Tarrech et al. 1999).

Another water market was developed by farmers in the Cariri region of the Ceara state in northeast Brazil, based on a spring-fed river. Rights to the water were allocated to farmers by farm size. Water is traded separately from land and enforced by farmers themselves. Generally, the trading system provided water rights holders with a secure water supply and flexibility in the allocation of water. The market was set up without any direct government involvement because it consists of a relatively small number of fairly homogenous farmers. They all grow sugarcane and know each other very well (Kemper et al. 1999).

# 4. GUIDELINES FOR IMPLEMENTING COST RECOVERY AND WATER PRICING

An essential part of any cost recovery or water pricing strategy is implementation. In this section, key factors that influence success and failure in implementing different cost-recovery and water pricing strategies are discussed.

### KEY FACTORS FOR IMPROVING COST RECOVERY

There are two key steps in 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 the 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 an accounting problem 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 crops grown and season of the year. Even if the appropriate water charge is determined, the more difficult step still remains: achieving high collection rates.

A key to achieving high collection rates, suggested by both literature and field experience, is financial autonomy (see Box 1). Without autonomy, collecting sufficient funds from users does not guarantee improved O&M services because revenues from water charges, in many cases, do not go back to the project. Instead, they are commingled with other taxes in the central treasury, as in India. 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—it does not matter whether it is a government agency, a local water user organization, or a private entity—will create a financial incentive for improving irrigation services. Better services will give farmers an incentive to pay their fees as well as an increased ability to pay because better service usually means higher farm incomes. Financial autonomy can be an important key to improved irrigation water management by providing a positive feedback system through a direct financial link between farmers and the water suppliers.

Financial autonomy 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 (see Table 3). In Bayi Irrigation District, China, payment defaulters' irrigation water is cut off 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 and Lu 1999). In this case, although financial autonomy is not mentioned, 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 percent collection rates at the same time (see Box 4).[7]

**Box 4. China: Integrated Circuit Card Automated Irrigation Charge Collection System In Groundwater Irrigation**

Shangdong is one of the biggest agricultural provinces in north China. Irrigation water accounts for between 70 and 80 percent of total water use, but water is scarce. To improve water use, a card automated system was adopted, in which irrigators buy prepaid IC cards. The card must be inserted into an automated server before water is released, and it stops when the card is removed. After each irrigation, the farmer receives a receipt, stating the amount of water used, the price paid per unit of water and the total deducted from the IC card. All servers are connected by the internet, so they are easy to control and monitor while the administrative costs are greatly reduced. The costs of each irrigation server is 1,000 Yuan (about US$120)—about equal in value to the water saved annually under this new system. With more than 200,000 IC servers, province-wide, the province saves about 5 billion $m^3$ of water annually.

*Highlights*

- This method makes a 100 percent collection rate possible. If the pricing structure is designed appropriately, full cost recovery will be achieved (assuming no stealing).
- It greatly reduced the personnel costs of administration. People no longer have to collect fees or open and close gates, and the end user is charged directly, reducing transactions among farmers and intermediate bureaucrats.
- The amount of water used is accurately recorded, and the charges are transparent. Therefore, it greatly reduces arguments over possible measurement errors.
- Farmers have full control over when, how, and how much water they use.
- The water charge is on a volumetric basis, which encourages reduced water use.

Source: Wang and Lu 1999.

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 and Perry 2003). Suppliers can also create awards or penalties to encourage their staff to achieve high collection levels. In Awati, China, staff members' salaries are completely dependent on the water charges they collect. Since they do not receive any government funding, they have to pay staff from revenues collected from farmers. The collection rate reached 98 percent after an institutional reform that established the financially autonomous management entity (Awati County Government 2002). In Bayi Irrigation District, China, the staff members receive rewards for turning in the fees by a deadline and are fined for late payment (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 the decisionmaking process, and the earlier the involvement, the better. In fact, they are more likely to be willing to pay for system improvements they help design. Coward (1980) cites the Laur project in the Philippines where the WUA had a chance to scrutinize the irrigation agency's rehabilitation expenditures on the project. He found the irrigation agency gained in terms of improved design as well as local commitment to 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 walk-throughs with farmers 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 and 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 example, 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 cases in Table 3 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 of major improvements in water fee collections after 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 to WUAs management and tradable water rights. By the end of 1997, 400 WUAs were operational, and each controlled an average irrigated area of 7,600 ha. Surveys conducted in 6 percent of the districts showed that water use per hectare had been reduced and maintenance improved. Water charges went up in most districts due to the financial self-sufficiency target, increasing more than 500 percent in some cases. Government subsidies, up to 1996, represented only 15 percent of O&M costs in the transferred districts. When collected, the depreciation cost could not be efficiently used due to restrictive financial regulations that prohibit the use of accumulated funds. In addition, inflation and devaluation of the currency discourage holding such funds. Yet 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 percent of farmers paid their assessed charges, mainly because they have to pay the irrigation charges before receiving WUA service (Palacios 1999).

The success of WUAs is 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. Eight Limited-Responsibility Companies, which are federations of WUAs, were operating and providing services to the WUAs by end of 1996. These companies are expanding their services beyond maintenance and management of the major infrastructure (Palacios 1999). One of the major reasons for the positive Mexican experience is the commitment at the highest level of government. The reforms have focused on the large schemes and farms; transfer in areas with small farms was started much later and appears more problematic (Simas 2002).

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 and Kalro (2000) found the majority of farmers in the districts who have experience with WUAs select WUAs as their first choice for supplying water. This is a significantly higher approval rate than in the two controlled districts without WUAs. Furthermore, in systems with WUAs, 75 percent of the farmers are willing to pay 25 percent higher water charges because of the better service they have received. The major reasons for choosing WUAs are: assurance of water delivery and supply, fewer disputes among farmers, better maintenance, and no corruption.

**Table 3. Cases Where Different Combinations Of Factors Increased Fee Collection Rate**

| *Cases* | *Financial autonomy* | *Additional incentives to collect* | *Incentives to pay* | | *User participation* | *System transparency* | *Collection rate* |
|---|---|---|---|---|---|---|---|
| | | | *Penalty for payment default* | *Penalty/reward to encourage better service* | | | |
| Awati, China (Awati Country Government 2002) | Yes | Staff salaries are directly tied to fee collection rate. | n.a. | n.a. | Yes, through WUAs | n.a. | 98 percent |
| Bayi ID China (Johnson et al. 1996) | Yes, managed by VIMG with revenue from water charges, labor contributions and sideline business profits. | Staff members receive their salaries and pensions from the fees collected. | Payment defaulters will not get water until they pay. | Staff members who do not deliver water on time are fined. | Yes, all lower level canals are managed by VIMG. | Two staff members collect fees together to check on each other; farmers get receipts stating amount of water used and price. | Almost 100 percent |
| Nanyao ID China (Johnson et al. 1996) | Yes, managed by VIMG | The VIMG get rewards for turning in collections early and pay fines for late payment. | n.a. | n.a. | Yes, all lower level canals are managed by VIMG. | n.a. | 95 percent |
| Shangdong China (Wang and Lu 1999) | n.a. | n.a. | Cannot get water if they do not pay. | Farmers are willing to pay because they have full control over water delivery time and amount. | n.a. | Yes, farmers get a receipt each time they use water, stating the amount of water used and the price. | 100 percent |

| *Cases* | *Financial autonomy* | *Additional incentives to collect* | *Incentives to pay* | | *User participation* | *System transparency* | *Collection rate* |
|---|---|---|---|---|---|---|---|
| | | | *Penalty for payment default* | *Penalty/reward to encourage better service* | | | |
| Yangtze Basin, China (Lin 2003) | Yes, the WSC and the WUAs are self-financing | n.a. | n.a. | Yes, WUAs improved system maintenance and efficiency. They deliver water on time and in the right amount. | Yes, farmers are involved in the decisionmaking process, and farmer representatives are in WSC. | Should improve system transparency by separating water charges from other taxes. | Goal is self-financing but collection rate not available. |
| Gujarat, India (Cornish and Perry 2003) | Yes, systems are owned by farmer groups. | Farmers own system and collect charges to cover costs. | Farmers failing to pay cannot get water in next season. | Farmer ownership | Yes, owned and managed by 3 to 10 farmers in groups | n.a. | Almost 100 percent |
| Haryana, India (Cornish and Perry 2003) | Partly, charges are set to cover O&M costs | n.a. | Land can be taken away from payment defaulter. | n.a. | Yes, each canal is managed by farmer groups. | n.a. | 85–95 percent |
| Mexico (Zeri and Easter 2003) | Yes, partly achieved the goal of financial self-sufficiency | n.a. | Farmers have to pay in advance to receive water. | Services improved and investments made to modernize infrastructure | Yes, managed by local WUAs | n.a. | 90 percent |

| *Cases* | *Financial autonomy* | *Additional incentives to collect* | *Incentives to pay* | | *User participation* | *System transparency* | *Collection rate* |
|---|---|---|---|---|---|---|---|
| | | | *Penalty for payment default* | *Penalty/reward to encourage better service* | | | |
| Alto Rio Lerma ID, Mexico (Kloezen et al. 1997) | Yes, O&M cost recovery increased from 50 percent in the years preceding transfer to120 percent after transfer. | n.a. | n.a. | Yes, a better match between expenditure and farmers' water need | Yes, farmers are involved in decisionmaking through WUAs. | Hiring professional administrative staff made financial system more transparent. | Almost 100 percent |

Note: n.a. = not available; WUA = water user association; VIMG = village irrigation management group; WSC = water supply corporation; O&M = operations and maintenance

Source: listed in table by case

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 (Box 4) 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 due 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 and Perry 2003).

In summary, Table 3 illustrates where financial autonomy and user participation combined with transparency have been key factors in achieving high fee collection rates. A major task for management 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 fully cover O&M may be too high relative to net farm income. In most cases, water charges are only a small share of farmers' net income, as shown in Table 2. Thus, low collection rates appear to be caused mainly by a lack of willingness to pay rather than by inability to pay. Examples from both China 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 collecting water charges or prepayment of water fees is required, or both, collection rates are much higher.

## KEY FACTORS FOR REDUCING WATER USE

To encourage farmers to use less irrigation water per hectare, water charges have 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 the 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 4 provides a summary of irrigation systems and factors that help reduce water use per hectare. There are two general approaches to 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 negatively sloping 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.[8] 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 two former areas that have very inelastic water demands produce high-value crops under controlled water conditions (fruit trees, vegetables, plastic-covered agriculture irrigated with modern technologies) (Hamdane 2002). In such cases, water prices have to increase substantially before they will significantly reduce water demand. In the process, farmers' income will be adversely affected. In parts of Spain, some estimates suggest that farmers' incomes would need to fall by 25 to 40 percent before an increase in the price of water would lead to significantly lower water consumption (Berbel and Gomez-Limon 2000). In a case in Iran, water prices would have to be raised from \$4/1,000m$^3$ to \$20/1,000m$^3$ to significantly reduce demand (Perry 2001).

Such a large increase in the price of water may not be politically acceptable. In addition, farmers must have alternative choices 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 elasticities 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 the indirect effects to account for only 17 percent 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 result in significant water savings. Thus, whether a water price increase will significantly reduce demand has to be determined and then, if it does, whether it is due to a movement along the demand curve or a shift in the demand curve. In cases of very inelastic demand, policies and practices that shift the demand curve to reduce water use should be used, as discussed below.

**Supporting institutions**

To shift the demand, alternative choices of crops or technology have to be available. A shift to a less water-consuming crop or to a water-saving technology can move farmers to a significantly lower level of water use. 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 (Box 3). The same strategy can be applied to 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 supports or taking back subsidies that encourage lavish water use. Low-interest loans for new equipment and technical assistance will help encourage farmers to adopt appropriate water-saving technology. In Gujarat, India, electricity used by tubewells is charged at a fixed rate per month and is heavily subsidized (Cornish and 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 use less groundwater per hectare and save more for future use. However, under certain conditions, with high enough electricity prices, farmers may move from electricity-operated pumps to diesel-operated pumps (Dinar 1994).

**Quotas**

Besides using pricing tools, there are several other means to reduce water demand. One is to use a water quota. A quota system is generally used to define the quantity of water that can be used in a given time period, by whom, and for what purpose (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 would be a fixed quota system for groundwater pumping with a specified annual rate of extraction in proportion to the land area of each water user. A second approach would be a fixed allocation of water shares to different canals and water users sharing water from the same canal. The fixed shares or quotas could also be allocated to WUAs (Tiwari and Dinar 2003). For example, in Maharastra, India, the WUA

receives 0.77, 0.86, and 0.62 million cubic meters of water during winter, dry, and summer seasons, respectively. They can also draw on any unused water quota from the previous season in the current season (Naik and Karlo 1998).

**Service Contracts**

Another way of reducing water use per hectare is to provide assurance that water will be delivered on time and in the amount demanded. If this is done, farmers will not have an incentive to store water on their field by overirrigating. Since system reform in Katepurna, India, farmers no longer flood their fields in the dry season and often do not irrigate in the monsoon season because irrigation scheduling is planned ahead according to water requirements and soil type. Farmers no longer 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, resulting in reduced water use per hectare. Not only are they saving 7.7 million $m^3$ annually, but they also expanded the irrigated area from 2,027 to 3,646 ha, an 80 percent expansion. 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 (Box 4). They were able to obtain the right amount of water when they wanted it. The end result is a 5 billion $m^3$ saving of irrigation water in the province annually (Wang and Lu 1999).

**Education**

A third effective mechanism for reducing water use can be public education campaigns to make farmers aware of water scarcity and convince them it should be treated like an economic commodity. 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, the formation of a WUA and the need for efficient water utilization were 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.

**Incentives**

Incentives can also be used to induce service providers to reduce conveyance loss. In some irrigation projects, conveyance loss is more than 40 percent of the total amount of water delivered. The most effective incentive is financial autonomy. If the service providers are completely responsible for the 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 4 provides examples of how a combination of different incentives can reduce water demand even when the water demand for one crop, with a given technology, is inelastic (unresponsive to price changes). When the major objective is to reduce water use, a combination of incentives should be used, not just higher water prices. Even if water cannot be metered effectively, other actions can be taken to help reduce overuse of irrigation water, including crop-based water fees.

**Table 4. Cases Where Different Combinations Of Factors Helped Reduce Water Use Per Unit Of Output**

| *Cases* | *Increase per unit price* | *Switch to volumetric measurement* | *Pricing structure* | *Alternative crop available* | *Water-saving technology availability* | *Assurance of water delivery* | *Education* | | *Result: Reduced water consumption* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Public awareness* | *Technical assistance* | |
| Awati, China (Awati County Government 2002) | 50 percent | Yes, from area based | Increasing block, with the second block price twice the first | n.a. | n.a. | n.a. | Yes, public education to promote water use efficiency | n.a. | Reduced by 50m$^3$/mu |
| Shangdong, China (Wang and Lu 1999) | n.a. | Yes. | Constant rate | n.a. | n.a. | Yes, IC machine installed. Farmers have full control over irrigation timing and amount. | n.a. | n.a. | Reduced by 5 billion m$^3$/ yr province-wide |
| Yangtze Basin, China (Lin 2003) | No | Yes, from area based | Constant at 0.032 Yuan/m$^3$ | n.a. | n.a. | Yes, WUA operated system delivers water on time and in the right amount, which reduce incentive to steal. | Yes, local water bureaus constantly hold training programs for farmers | n.a. | Each WUA on average saves about 1.18 million m$^3$ annually. |
| Katepurna, India (Belsare 2001) | n.a. | Yes, from area based | Constant rate | Yes. | Yes | Water delivery schedule is developed earlier based on soils, crops and farmer input | Yes, public education campaign through various local media | On-farm training for water-saving technology | Save 7.71 million m$^3$/yr |
| Tunisia (Hamdane 2002) | Yes, more than doubled from 1991 to 2000 | Always has been volumetric | Constant at $65.8 /1,000 m$^3$ | n.a. | Yes, government provides low-interest loans for water-saving equipment. | n.a. | Yes, encourage user participation and raise awareness through educational programs | n.a. | Water users are more efficient, and future supplies are more secured |

| *Cases* | *Increase per unit price* | *Switch to volumetric measurement* | *Pricing structure* | *Alternative crop available* | *Water-saving technology availability* | *Assurance of water delivery* | *Education* | | *Result: Reduced water consumption* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Public awareness* | *Technical assistance* | |
| Mula area, Spain (Del Amor Garcia 2000) | n.a. | n.a. | n.a. | n.a. | Yes, system improvement and modernization financed by public and farmers', which greatly reduced water loss | Yes, farmers have full control over their water share. An innovative water teller is used so farmers can program their water use. | n.a. | Yes, technical training is provided to farmers | Water loss reduced from 1.2 $Mm^3$ in 1987 to 0.14 $Mm^3$ in 1998 |

Source: listed in table by case

# 5. CONCLUSIONS AND RECOMMENDATIONS

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 irrigation system type, management structure, government policies, and institutional arrangements (see Table 5).

### AUTHORITY AND RESPONSIBILITY TO FARMERS

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.

- A transparent process, where farmers help decide what components should be included in the costs to be recovered from them through water charges, is an important stepping stone toward increasing their authority. As part of this process, farmers need to be consulted early about the design and level of service they want, as well as the extent and type of any improvements in the system infrastructure. This type of consultation was done in the Laur Project in the Philippines (Coward 1980). Allowing farmers to participate in decisionmaking improves their willingness to pay water charges.

- To obtain high cost-recovery rates, farmers should not only agree on the costs to be recovered but also see that the fees collected are used to maintain and improve "their" 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*. One good approach is to have the water supply entity or the WUA collect and keep most of the fees for use in "their" system. This is one of the big benefits of having a financially autonomous water supply entity, as in a number of the systems in China and Mexico (Table 3). In addition, a general government effort to liberalize and decentralize the economy seems to facilitate such changes in the water sector (see Table 5).

- 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 discussed above (e.g., the Yangtze Basin Water Project in China). Again, such reforms seem to occur after a country has carried out a general economic liberalization (see Table 5).

- More should be done to reduce and prevent corruption in water distribution. 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 changes (in addition to the “informal” charges) can be very difficult. Establishing an active WUA is definitely an effective way of involving farmers in the decisionmaking process and improving service quality. However, extra attention must be paid to developing checks and control mechanisms to prevent farmers from developing the same bad habits as the former irrigation officials[9]. One good option would be to establish and finance a state-level oversight board or an auditing agency to review WUA operations.

**Table 5. Country Conditions And Irrigation Practices**

| *Country Conditions and Policies* | *Good Practices* | *Pricing structure that encourages water savings* | *Water-saving technology available* | *Assurance of water delivery* | *Public education/ technical assistance* | *Water market* | *Management transfer* | | *System transparency* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Financial autonomy* | *User participation* | |
| Physical conditions | Water scarcity and drought common | Awati, China; Katepurna, India; Tunisia | n.a. | Shangdong, China | Tunisia | n.a. | Gujarat, India | Gujarat, India | n.a. |
| | Poor condition of infrastructure | n.a. | Katepuna, India; Mula, Spain | Katepurna, India; Mula, Spain | Katepurna, India Mula, Spain | n.a. | Mexico | Katepurna, India | n.a. |
| Economic/ political conditions and policies | Economic liberalization | Yangtze, China | n.a. | Yangtze, China | n.a. | n.a. | Awati, Bayi, Nanyao, Yangtze, China; Mexico | Indonesia; Mexico | n.a. |
| | Decentralization | Shangdong, China | n.a. | Shangdong, China | Yangtze, China | n.a. | Awati, China; Gujarat, Indai; Mexico; Sri Lanka | Bayi, Nanyao, Yangtze, China; Mexico; Sri Lanka; Indonesia | Shangdong, China Alto Rio Lerma, Mexico |
| | Serious financial constraints | n.a. | n.a. | n.a. | n.a. | n.a. | Bayi, Nanyao, Awati, China; Mexico | Bayi, Nanyao, Awati, China; Mexico | Bayi, China |
| Legal/ institutional arrangements | Definition of water rights | n.a. | n.a. | Haryana, India | n.a. | Siurana-Riu decanyes, Spain; Cariri, Brazil | n.a. | Haryana, India | n.a. |
| | Effective local system for enforcing water use rules | n.a. | n.a. | Bayi, Nanyao, China; Haryana, India | n.a. | Siurana-Riu decanyes, Spain | n.a. | Alto Rio Lerma ID, Mexico | n.a. |
| | Rights to | Awati, China | n.a. | Bayi, Nanyao, | Bayi, | n.a. | n.a. | n.a. | n.a. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | establish WUAs | | | China; | Nanyao, Awati, China | | | | |

Note: n.a. Not Available
Source: Authors

## AUTONOMOUS WATER SUPPLY ENTITY

Another effective tool to improve cost-recovery and pricing is to make the irrigation water supply entity (WSE) financially autonomous, similar to the supply corporation created at the Tieshan Irrigation District in the Yangtze Basin, China (Box 1). Making the WSE financially autonomous changes the incentives for cost recovery and pricing.

- If the WSE's are financially autonomous, they have a financial stake in using incentives and penalties to encourage farmers to pay their water charges. Incentives could include: providing high-quality and timely water service. Penalties could include stopping water delivery to defaulters, charging a higher rate for late payment, making farmers pay water charges before receiving any water,[10] or all these measures.

- 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. For example, for failing to deliver water at the scheduled time and for the right duration, WSE personnel would be fined as is done in the Bayi Irrigation District, China. Alternatively, good performers would receive a bonus.

- 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 done in Katepura project in India. After the schedule is developed, it should be widely advertised along with a statement regarding the water charge farmers are expected to pay. In addition, any changes in the schedule should be quickly conveyed to every farmer.

- The WSE will also have a strong incentive to invest in improved infrastructure to improve their control over water use. The improved water control will allow them to provide better services as well as better measures of water delivered. This will, in turn, make it easier to monitor and base fees on the quantity of water delivered. In several of the cases reviewed, improved water control saved water and enabled the WSE to increase revenues by selling the water they saved, as has occurred in the Yangtze project in China.

## EQUITABLE AND SIMPLE FEE STRUCTURE

The fee structures have to be equitable, administratively simple, and easily understood by users and those administrating 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 (Box 2).

- 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 to all users.
- For a new project or any major improvement in infrastructure, users' ability and willingness to pay should be assessed. As shown in Table 2, if the project is economically feasible and government agricultural price policies do not disadvantage farmers,

willingness to pay is likely to range from about 5 percent to 30 percent of net farm income, depending on service quality.

## CONSERVATION AND REALLOCATION OF WATER

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 reduce water use per hectare.

- One good way to measure water use is output per unit of evapotranspiration (ET). Water removed from a basin through ET is water lost for reuse, so it is really ET that has to be cut.

- When water metering is not possible, area-crop and area-technology based water charges should be designed to strengthen farmers' incentive to shift to crops that need less water, or to shift to water-saving technologies, or both (box 3). This works only if alternative crops and technologies are available and can be adopted without a significant drop in net farm income.

- Where feasible, water markets should be encouraged as a means of improving water allocation as well as water conservation. One clear advantage of water markets is the flexibility they provide for moving water to higher valued uses while, in most cases, leaving both buyers and sellers better off. A number of countries, such as Chile, the U.S. West, Spain, and Australia have made effective use of water markets.

- 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. This has been done in a number of projects including the ones in Awati (China), Katepara (India), Yangtze (China), and Tunisia. In other words, users need to understand the importance of conserving water. Farmers will also need training and technical assistance to switch to better irrigation cropping practices and technologies. Special training programs will be needed before the irrigation water is made available where irrigation is being introduced for the first time.

# APPENDIX 1: CONSULTATIONS ON COST RECOVERY AND IRRIGATION WATER PRICING

*The World Bank Personnel Consulted*

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Michael Carroll
Rita Cestti
Manuel Contijoch
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Nihal Fernando
Vijay Jagannathan
Qun Li
Doug Olson
George T. K. Pitman
Richard Rideinger
Joop Stoutjesdijk
Mona Sur
Satoru Ueda
Dina Umali-Deininger

*Types of Questions Asked*

- Are project costs charged to farmers inflated by irrigation officials?
- How important do countries consider cost recovery and water conservation?
- How are water charges used once they are collected?
- How are fee collections made and by whom?
- Do irrigation project managers have incentives to give good service?
- Have financially autonomous organizations been used to manage irrigation projects and if so, how effective have they been?
- Has project turnover to farmers been effective? Did it improve service delivery?
- Is farmers' ability to pay an important issue for cost recovery?
- How much of project cost should farmers pay? Why?
- What incentives are important in obtaining improved cost recovery?
- Should farmers invest their money in the irrigation project as a prerequisite for receiving irrigation services?
- What incentives are there for farmers to pay water fees?
- What irrigation project reports should I review?
- What incentives do farmers have to form WUA such as keeping a share of fees collected in their project, or helping make water allocation decisions?
- How do WUAs support themselves financially?
- What enforcement problems exist with the collection of water charges?

# APPENDIX 2: CASE STUDIES, SUMMARIES, AND LESSONS LEARNED

**Table A2.1: The Case Studies**

| *Country* | *Project/area covered* | *Reference* |
|---|---|---|
| BRAZIL | Batateria Spring of Ceara<br>Ceará, Northern Brazil, 2004<br>Jaiba Project, 1995 | Kemper et al. 1999<br>Lemos and Oliveira 2004<br>Azevedo 1997 |
| BULGARIA | Bulgaria, 2001 | öKo Inc. 2001 |
| CHINA | Awati County, Xinjiang 2002<br>North Plain, the Nanyao and Bayi Irrigation Districts<br>Shandong 2001 Zhanghe Irrigation District, China 2003 | Awati County Government 2002<br>Johnson et al. 1996<br><br>Wang and Lu 1999<br>Lin 2003 |
| EGYPT | Egypt,1995 | Perry 1995 |
| INDIA | Gujarat 2003<br>Haryana 2003<br>India Water Resources Management Sector Review<br>Katepurna 2001<br>Mula scheme and Bhima scheme, Maharashtra, | Cornish and Perry 2003<br>Cornish and Perry 2003<br>World Bank 1998<br><br>Belsare 2001<br>Naik and Kalro 2000 |
| INDONESIA | Preliminary Impact Assessment, Irrigation Reform, Phase I, 1999–2000<br>Indonesia Irrigation Subsector II<br>Indonesia: Participatory Management | Alaerts 2003<br><br>Bruns and Helmi 1996<br>World Bank 1996 |
| IRAN | Zayandeh Rud Basin, Esfahan Province, 2001 | Perry 2001 |
| PHILIPPINES | Laur Project | Coward 1980 |
| MACEDONIA | Macedonia | Cornish and Perry 2003 |
| MEXICO | Development of Water User Associations<br>Alto Rio Lerma Irrigation District | Zekri and Easter 2003<br>Kloezen Garces-Restrepo and Johnson 1997 |
| MOROCCO | Morocco Water Sector Review<br>Tadla scheme<br>Haouz scheme | World Bank 1995<br>Cornish and Perry 2003<br>Cornish and Perry 2003 |
| NEPAL | Nepal<br>Sunsari Morang Irrigation Project II | World Bank 1996<br>Cornish and Perry 2003 |
| NIGER | Niger, 2000 | Abernethy 2000 |
| PAKISTAN | Pakistan, 2001<br>Sindh Province | Ahmad 2002<br>Cornish and Perry 2003 |
| SPAIN | Mula Area Murcia<br>Siurana-Riudecanyes | Del Amor Garcia 2000<br>Tarrech, Marino, and Zwicker 1999 |
| SRI LANKA | Sri Lanka | Samad and Vermillion 1998 |
| UNITED STATES | San Joaquin Valley, California | Schoengold et al. 2004 |

## BRAZIL

### Batateria Spring of Ceara (Kemper et al. 1999)

Batateria Spring is in the south of Ceara (Northeast Brazil). This region is semi-arid but generally has higher precipitation than the interior of the state. It is also the only region in Ceara with abundant groundwater resources. Twelve large springs in the area produce 40.5 million $m^3$ of water per year (Mont' Alverne et al. 1994). The Batateria Spring, the most important one, serves a relatively homogenous sugarcane-growing area, where the farmers, who set up their own water allocation system in 1854.

The farmers developed a system of water rights using an old Portuguese measure called *telha*. One telha corresponds to a volume of 64.8 $m^3$ per hour. To start, the farmers divided 22 telhas among themselves and reserved one telha to maintain a minimum flow of water in the river. Today, however, the "extra telha" has disappeared, and the entire flow is allocated for agricultural use. The farmers have allocated the telhas based on farm size.

Enforcement has been done mostly by the farmers. In the past, larger local farmers had the political power to punish water thieves. Today, each farm has a *levadeiro* [the local judicial system] to monitor the operations. Outsiders can, but rarely do, bribe the levadeiro to get water. A water market has developed, and water is traded separately from land. Anybody can buy a number of telhas from a system user without any linkage to the original ownership right to land. Today, the yield from the spring has diminished considerably; and the water price has been halved over the past century. The reason is that sugarcane is no long as highly valued a crop as it once was, so the decreased price for water reflects its lesser valued use. This system has generally performed satisfactorily, providing water security for water right holders and flexibility in water allocation.

*Highlights*
This system of water rights and trading developed in the absence of direct government involvement. Its success is largely due to the homogeneity of the small local community and farmers' willingness to work together to provide a collective service.

### Ceará, Northern Brazil, 2004 (Lemos and Oliveira, 2004)

Ceará's Water Resource Management Company (COGERH), created in 1993, was responsible for implementing the Jaguaribe/ Banabuiú Participatory Management project. Three main factors led to the creation of COGERH: (1) political reform, involving decentralization and modernization of local government administration; (2) a particularly long and costly drought crisis that exacerbated the conflict over water allocation; and (3) financial support from the World Bank that encouraged state government reform. The most innovative aspect of COGERH's approach was to organize user commissions to debate and decide on the use and management of bulk water in the basin. Since 1994, the user commissions have met several times each year and more frequently in the months right before the dry season. They use reservoir scenarios as a tool to decide how much water to discharge from the reservoir and how to distribute it among user groups. They set aside enough water to guarantee human consumption for at least two years and then built several alternative scenarios simulating different levels of discharge. After developing the alternatives, they debate which scenario best fits the current water availability and different climate forecasts for the next year.

This decisionmaking tool has been successful in three ways. First, it increased the transparency of the decisionmaking process. Second, it allows users to make better informed decisions after developing the alternative scenarios. Third, it helps build a trust relationship between the service provider (COGERH) and the water users. In 2000, after a year of low rainfall, COGERH decided to reduce the amount discharged. The amount discharged declined incrementally over the next seven months, forcing users to cut back on irrigation or other water using activities. This decision helped avert a more serious water crisis and proved that users are

capable of cutting consumption voluntarily. However, because user commissions do not have an official mandate, their role may be undermined by their inability to enforce decisions among users or institutionalize their roles within the water management system. The user commissions were created during the nationwide political reform and transition toward democracy. Therefore, further studies are needed to see whether user commissions can survive political changes when more conservative policymakers are in power.

### Jaiba Project, 1995 (Azevedo 1997)

The Jaiba project is one of the best managed public irrigation projects in Brazil. The objective is full cost recovery, including operation and maintenance (O&M) costs and capital costs. Jaiba has a two-part water charge, K1 and K2. K1 reflects project capital costs calculated on a 50-year repayment period and a subsidized interest rate. K1, which was $3.69 per hectare per month in 1995, accounts for 26 percent of total costs. K2 is supposed to cover all O&M costs and based on the volume of water used. K2 is subdivided into two components: one representing fixed O&M costs and the other the variable costs. K2 was $10.11/m$^3$ in 1995. Farmers choosing not to grow crops one season would still be responsible for the fixed O&M costs. K1 is paid to the sponsoring federal agency, and K2 is paid directly to the water user districts. After the project started operations, the collection rate was 66 percent, and the cost-recovery rate was 52 percent. Nationwide, the K1 component is standard ($3.69 /ha). K2 is varied by whether the project is public or private and whether water is supplied by gravity or pump.

*Highlights*

- The pricing structure design conveys the idea of both cost recovery and water revenue allocation.
- The water charge for O&M has both a fixed and a variable component.

## BULGARIA

### Bulgaria, 2001 (öKo Inc. 2001)

After the political and economic changes of 1989–90, the Central East European (CEE) countries introduced fundamental changes in their agricultural policies, particularly modifications of the ownership structure.

In Bulgaria, the Ministry of Agriculture and Forestry (MOAF) is responsible for formulating and executing national agricultural policy. MOAF holds all shares in the Irrigation Systems Company (ISC), a joint stock company responsible for management, operation, and maintenance of all state-owned irrigation and drainage systems. In 1999, 176 irrigation water user associations (IWUAs) were established with assistance from the ISC. However, only a few irrigation systems have been transferred to IWUAs.

Irrigation water prices depend on the source of irrigation—gravity or pump, and there is no uniform pricing system nationwide. Each ISC and IWUA uses a different method to calculate prices. The pricing scheme consists of an abstraction fee and a volumetric charge. The average price was between $0.01and $0.085/m$^3$ in 1996–98. The prices for pumping irrigation water are usually two to three times higher than for gravity-fed water. Revenue from water charges usually covers only part of the O&M costs and in some cases part of the capital costs. Subsidies to ISCs make up the difference between prices and costs.

*Highlights*

- This is an example of adjustment in the period following economic and political reform.
- The decline of agriculture production and irrigation activities is due to water price increases and change in the ownership structure.
- Irrigation activities are effective where farmers join forces and form IWUAs.

## CHINA

### AWATI COUNTY, XINJIANG (Awati County Government 2002)

The governmental agency originally in charge of irrigation water services was reorganized and is now a financially autonomous enterprise. Staff salaries are directly related to fee collection rates. Through water user associations organized in each village, a public education campaign program is operated. Since the reform, water prices, which are based on volume used, have increased by 50 percent Water quotas have been set for each farm. For any water exceeding their quota, farmers must pay twice the normal price. The amount of water used per mu (0.067 ha) decreased by 50 $m^3$ after the reform, and the fee collection rate is 98 percent.

*Highlights*

- Financial autonomy and tying staff salaries to collection rates have given service providers a strong incentive to collect fees.
- Farmers have an incentive to use water more efficiently because of the increasing block rate pricing scheme and higher per unit prices.
- Participatory management by local WUAs who involve farmers in the decisionmaking process has improved communication between water suppliers and users.
- Public education programs are also used to increase water use efficiency.

### North Plain, Nanyao and Bayi irrigation districts China (Johnson et al. 1996).

In the Nanyao Irrigation District, the two top-tier canals are managed by the irrigation district, and the third and lower level canals are managed by village irrigation management groups (VIMG). All VIMG personnel receive their salaries from water charges. The water fees are calculated according to the estimated volume of water delivered and then translated into an area-based charge. The charge is lower than the provincial average charge because farmers in that area are relatively poor and a high water price is considered inequitable.

If the VIMG collects 100 percent of the fees by the end of March, it retains 5 percent of the fees; if it reaches 100 percent by the end of April, it retains 3 percent; and if it collects less than 100 percent by the end of May, it must pay a fine of 3 percent of the uncollected amount. The fees for the year should be collected by the end of May, 10 days before the first irrigation. Fee collection rates in 1993 were 90 percent, 95 percent, and 97 percent for March, April, and May, respectively. Before government reform, the water fee collection rate was 100 percent because the commune paid the charges. At the beginning of the reform in 1984, when individual farmers paid their own bills, the collection rate dropped to 85 percent and lower until 1991. By 1993, after the irrigation management reform, the collection rate rose to 95 percent and higher.

All 67 of the Bayi Irrigation District 67 staff members receive their salaries and pension from the district—none of them are civil servants under the county Water Conservancy Bureau. The irrigation district is an independent public utility and not part of the government. Most villages have a surcharge on their water fee (2 to 5 percent) to pay the VIMG staff members. The district has an irrigation management division, a diversified management division to develop sideline business, and five technical and administrative offices to supervise farmers.

There is both a fixed area fee of 1.5 yuan/mu and a volumetric fee of 7.11 yuan /$m.^3$ A higher price may be charged if the actual delivery costs are higher because water comes from another county with its own fee structure. The water charges are collected through the VIMGs, 3 to 5 days before the village's scheduled water turn. The VIMG broadcasts announcements of pending water delivery 3 to 5 days in advance to remind farmers to bring in their payment. At least two staff members wait at a designated location for farmers to pay. Each farmer is given a receipt upon payment. On average, 90 percent of farmers pay before delivery. Farmers who do not pay still get a one-time reprieve and receive water, but if they remain in arrears, they must pay all back bills before receiving any more water. The change in the collection rate in the Bayi Irrigation District after reform

was much more striking than the one in the Nanyan ID: it dropped from 100 percent to 5 percent. Now collections have returned to nearly 100 percent.

All VIMGs are responsible for scheduling, managing, and recording water deliveries, which are arranged to irrigate one farm at a time along a given canal. The director of the Baiyi ID fines staff members who do not deliver the right amount of water to branch canals on time and for the right duration. Also, the district provides a small bonus to VIMGs that use less water than planned. Farmers who damage structures are required to repair them and pay a fine. Farmers caught illegally opening field gates must pay a water fee twice the normal rate.

The district began to create sideline businesses in 1984. By 1994, it had 11 kinds of sideline businesses, including designing small irrigation projects, fitting water pipes and taps, repairing farm machinery and agricultural product stores, and constructing buildings. Profits from these businesses provide the district with 7 percent of its total revenue, and the production activities create significant employment opportunities.

Both districts report that they no longer receive central government funds for O&M. Their revenue comes from the fixed area fee, the volumetric fee, and an annual labor contribution to system maintenance (between 10 and 20 working days a year from each farmer).

*Highlights*

- The VIMGs are financially autonomous.
- The VIMGs are rewarded if water fees are paid early and are penalized for late payments or defaults.

### SHANDONG (Wang and Lu 1999)

The integrated circuit (IC) card automatic irrigation collection system (CAIC) operates in Shandong's pump irrigated area. Under this system, irrigators must buy prepaid IC cards. The card must be inserted into a server before water is released. The flow stops when the card is removed from the server. After each operation, farmers receive an electronically printed receipt, stating the amount of water used, price paid per unit of water, and the total amount of money deducted from the card. All servers are Internet-connected, so control and monitoring are easy, which greatly reduced administrative costs. Each irrigation server costs 1,000 yuan (about US$120), about the same value as the water saved each year. The new system pays for itself in one year of operation.

Shangdong is one of the largest agricultural provinces in north China. Irrigation water accounts for between 70 and 80 percent of the total water use. However, water is extremely scarce, and the water per capita is only one sixth of the national average. With more than 200,000 IC card controlling irrigation servers province-wide, the province saves about 5 billion $m^3$ of water annually.

*Highlights*

- The CAIC ensures that water fees are paid on time. This method makes a 100 percent collection rate possible. If the water charges are designed appropriately, they will achieve full cost recovery, assuming there is no water stealing.
- The system greatly reduced administrative costs, because personnel no longer have to collect fees or open and close gates.
- The amount of water used is accurately recorded, and the charges are transparent. This greatly reduced disputes over measurement error.
- Farmers have full control over how much, when, and how to use water.
- Water charges are volumetric, which encourages efficient water use
- At the administrative level, water use is much easier to control and monitor through automation, as long as stealing is not a problem.

## Yangtze Basin Water Resource Project, 2003 (Lin 2003)

Before the Self-financing Irrigation and Drainage District (SIDD) program, there were several major problems. First, funds obtained through the collection of water fees were often used for other purposes. Second, area-based charges were used, and payments were not based on the volume of water used. Third, during the peak irrigation seasons, farmers conspired against one another to get better access to irrigation water. Fourth, some water user groups had been established, but they were not permanent organizations. The group leaders were appointed by local officials and not elected by farmers. Thus, the lack of user participation and ownership gave farmers little incentive to maintain the system.

The reform goal was to establish a self-financing and self-managing system consisting of two integrated parts: the water supply corporation (WSC) delivering water from the headworks and the water user associations (WUAs) operating at the local level. A WUA executive committee was elected by farmers at a water users' conference. Villages have helped mobilize community human resources for both the WUA conference and the executive committee election, which helped expand farmer participation and WUA operations. The WSC charter also requires seats on WSC board of directors for farmer representatives from the WUAs so that farmers participate in WSC management and decisionmaking. After the transfer of the local irrigation system, irrigation project authorities and local water agencies constantly held training programs for farmers, which helped enhance the WUA's operational capacities.

Establishing WUAs created a number of benefits. First, WUA control of local irrigation saved water and labor and shortened the irrigation time cycle. Water is now delivered on time and in the right amount. The increased availability of irrigation water under WUAs reduced the incentive to steal. Second, WUAs improved system maintenance in both the main canal and the lower distribution network. Farmers are investing labor and funds because they now view the irrigation projects as their own. Third, irrigation costs were reduced in multiple ways once WUAs were introduced along with volumetric pricing. Farmers now use water more efficiently, and delivery is also more efficient. On average, each WUA saves about 1.18 million $m^3$ of water annually. Fourth, productivity is improved. In Zhanghe, after introducing WUAs, the average crop yield increased by 6 percent, 2.5 percent of it due purely to irrigation improvements. Finally, the irrigation improvements also helped reduce poverty. In most WUA areas with improved irrigation services, even poor farmers can now secure their harvest regardless of weather.

However, problems still exist. Water charges are too low to cover the full costs. For example, in Hunan province, water charges were ￥0.032/$m^3$ and the estimated costs were ￥0.10 to ￥0.15/$m.^3$ In addition, farmers are not willing to pay more for irrigation since they already have high taxes, fees, and compulsory labor sharing. Furthermore, the farmers are paying the O&M costs of the WUAs plus the water fee charged by the WSC. Thus, more effort is still needed to improve system transparency, separating water charges from other taxes.

*Highlights*

- Self-financing and self-management were the keys to improved water management. Farmers elect their WUA representatives and are involved in decisionmaking.
- Support from government, especially from local township authorities, was critical to success.
- The traditional top-down, command approach was replaced by a bottom-up participatory approach at the local level.
- Current water charges still do not cover all costs, but farmers already have a heavy burden from other fees and taxes. It is important to separate water charges from other fees. This is a critical step towards fair and transparent pricing and will also make self-financing easier.
- The SIDDs have been successful because they were established with project support, favorable policies, and a source of steady funding.

## Hubei Zhanghe Irrigation District (Zhang et al. 2003)

To investigate the effectiveness of water user associations (WUAs) in irrigation water management, a survey was done in Hubei Zhanghe Irrigation District, the first place in China to experiment with WUAs. This evaluation report shows that WUAs are generally successful, but some organizational changes are still needed.

Since the establishment of WUAs, all kinds of conflicts over water use have been dramatically reduced. The survey found that 80 percent of the farmers spend much less time waiting for water and supervising irrigation because WUAs have specialized personnel who supervise water delivery. Furthermore, 77 percent of the farmers think that irrigation channel conditions have been greatly improved. Therefore, water delivery is much faster and more efficient than before. The disadvantaged groups, such as disabled people or families without male adults, are especially appreciative of the WUAs because delivery schedules are well planned and they no longer have to fight for water. The fee collection rates are much higher, because WUAs have farmers pay part of the water fee before delivery and the rest after delivery. Also, water use was reduced by an average of 30 percent after the establishment of WUAs, for two reasons. First, the WUAs made many improvements in the infrastructure, which reduced water loss. Second, because farmers are well informed about the increased unit water price, they try to conserve water during irrigation.

Some problems persist, however. First, in terms of user participation, farmers are largely involved in construction and maintenance of irrigation infrastructures, but not in the water allocation decisions. Also there are no checks and control mechanisms among the WUAs. The majority of people running in the WUA elections are village officials instead of ordinary farmers. In most places, village officials are still responsible for collecting water charges and sometimes village officials divert water fees for other purposes. The survey found that 80 percent of the farmers think WUAs should have the legal rights to collect the fees. WUA finances are not transparent to most farmers. Finally, many farmers do not understand the basic concepts of WUAs. They still think WUAs are an extension of government and do not feel they “own” the organization.

# EGYPT

## EGYPT, 1995 (Perry 1995)

Several studies in 1995 by the International Irrigation Management Institute (IIMI) measured the impact of different pricing alternatives on the agricultural sector in terms of irrigation water used and farm income. Among the findings, in Egypt, crop-based water charges were as effective as volumetric charges.

- A fixed rate of $52 per hectare, irrespective of crop or water use, resulted in a 4.5 percent fall in farm income, but had no effect on the choice of crop or technology.
- A crop-water charge per hectare, proportional to the calculated average water consumption of each specific crop resulted in a 2.4 percent fall in farm income, while demand for irrigation was water reduced by 3.5 percent and the returns to water increased by 2.7 percent.
- A volumetric charge based on the quantity of water delivered resulted in impacts virtually identical to those in the second case. The key factors explaining the different responses appear to be the availability of a wide choice of crops to grow. In addition, water charges were only a relatively small percentage of the farm income.

*Highlights*
Water price increases, when related to water use, can have a significant impact on water use efficiency (reduce the quantity of water demanded), when alternative crops or water-saving cropping practices or irrigation technologies are available.

## INDIA

### GUJARAT, 2003 (Cornish and Perry 2003)

Surface water irrigation is limited in northern Gujarat and groundwater development is extensive. Deep tubewells are the major means of irrigation. Because groundwater use is uncontrolled, a competitive water market has developed with no concern for sustainable resource use. The irrigation schemes are privately owned and developed. Most are owned by a group of 3 to 10 farmers who have developed management systems that are financially profitable under the current low government electricity rates. The water charges are volumetric and are set to cover system operation and maintenance (O&M) costs. The owners have made the capital investments collectively based on the area they propose to irrigate and the estimated profits from increased agricultural production. The current water charges cover full O&M costs. The issue of payment default does not arise because each farmer has a capital stake in a well, and farmers who fail to pay are barred from access to water in the next season.

However, the charges for electricity used by the tubewells are a fixed charge per month and do not cover the full costs of electricity generation, because electricity rates are subsidized. Consequently, the marginal cost of electricity is zero, and the water charges do not include anything for the scarcity rent or marginal user cost of the groundwater.

*Highlights*

- Ownership provides an incentive to achieve full cost recovery.
- Water users have an incentive to pay water charges, because defaulters will not receive irrigation water in the next season.
- There is no incentive to prevent groundwater overdrafting.

### HARYANA, 2003 (Cornish and Perry 2003)

Surface irrigation is the predominant water source in the three areas studied: the Bhakra command, the Western Yamuna command, and the lift irrigation areas in southern Haryana. Available water is divided equally over the entire command area through a canal system that automatically apportions the water among farmer groups (300 ha or 100 farmers), who share the supply in rigidly fixed turns. Allocation and scheduling of water among canals is the responsibility of the irrigation department. Once the water reaches the outlets, farmers are fully responsible for operation and maintenance (O&M). This system has proven to be one of the most productive in India, because it provides strong peer pressure governance. A farmer who steals a turn from another farmer can cause instability over the entire canal. The system can also have serious problems if the irrigation department does not provide water on time and for the planned duration and quantity.

The charges are set to cover the O&M costs but not capital costs. Charges are based on area and crop. Fees are collected by the state revenue department. Collection rates are high, between 85 and 95 percent, because the government can take land away from defaulters.

Water charges are about 0.5 percent of net farm income. The irrigation department achieves full O&M cost recovery by allocating only 33 percent of the overall project costs to irrigation (which uses 92 percent of the surface water) and by charging a low price (less than one-twentieth of the price to industrial, municipal, and other users). The price would be 3.2 times higher if the costs were allocated by share of water (92 percent) used ($8/ha instead of $2.5/ha). The actual O&M costs overall are still very low. This is due to highly centralized management, limited staff requirements, and substantial farmer participation in O&M. Also, since the municipal and industrial users share more costs, they receive better services and supply priority during shortages.

*Highlights*

- The system combines effective overall government supervision and participatory management through WUAs.
- Farmers have strong incentives to pay fees, because land can be confiscated for nonpayment.
- System design creates peer pressure against water stealing.
- Haryana is an example of cost sharing among different types of beneficiaries in the same water system.

## Katepurna, 2001 (Belsare 2001)

The irrigation improvement and reform project in Katepurna in Eastern Maharahstra state took place in 1998. Before the reform, farmers were reluctant to pay fees because they had no assurance of receiving water at the right time and in the amount they wanted. Heavy water loss led to drainage problems and difficulties in transporting products to market. There was no coordination among beneficiaries and project authorities.

The new project included the following improvements and reforms:

- The leaky canal structures were repaired.
- The irrigation schedule was planned in advance. Scheduling was based on crop water requirements and soil types. Farmers are now assured of adequate and timely water supplies.
- Water charges are volumetric instead of area based. Flow-measuring devices have been installed at canal head to measure the canal discharge, which has improved efficiency.
- Participatory irrigation management (PIM) was promoted by the formation of water user associations (WUAs). A project-level coordination committee was formed with WUA representatives to plan, coordinate, and monitor irrigation water use. Farmers were involved in project decisionmaking and management. Incentives were given to irrigation officers as well as to WUAs. On-farm training was conducted for farmers and project personnel. Field visits were organized to share successful WUA experiences. Farmers were trained to adopt water-use efficient irrigation technologies such as furrow irrigation.
- A public awareness campaign was conducted to promote WUAs and improve water use efficiency through newspapers, radio, exhibitions, pamphlets, posters, and slogans written on compound walls, canal structures, offices, and public places. To motivate irrigators, cultural groups were formed by department staff members, and village cultural programs (songs, dramas) were arranged.

In 1998–99 to 2000–2001, the average area irrigated in the Katepurna project command went from 2,027 ha to 3,646 ha, with annual water savings of around 7.71 million $m^3$. The Katepurna experiment is being tried, with similar success, in other projects in the Akola district.

*Highlights*

- The project provides economic incentives to conserve water because area-based water charges were changed to volumetric charges.
- Public education campaigns were conducted through different local media and on-farm training, and technical support was provided to promote water use efficiency.

## India Water Resources Management Sector Review (World Bank 1998)

Problems and constraints found in the World Bank–Government of India Water Resources Management Sector Review include:

- Poor maintenance, poor design and construction quality, and delayed maintenance.
- Ineffective control structures, meaning that canal operators cannot deliver water on time and in the right volume.

- Lack of public sector accountability because there is no incentive linking farmers and service providers.
- Minimal involvement of farmers in irrigation management.
- Poor cost recovery due to excessively low water charges.
- Inadequate funds for operation and maintenance (O&M).
- No incentive for water-use efficiency and conservation due to high public subsidies and area-based water charges.

The World Bank and the Government of India worked together to devise the reform agenda. Plans include:

- Water charges will be substantially increased to cover O&M costs. Full cost recovery will be achieved through annual increases in a time-bound program not to exceed three years.
- The direct collection of water charges will be shifted to WUAs. They should collect water charges and use the revenue to finance their operations. They will be responsible for ensuring high collection rates.
- Volumetric pricing will be introduced where possible.
- Cost-effective O&M will be emphasized.
- Service improvement and provision will become client-driven.
- Efforts will be made to persuade farmers to share in investment costs to help create a sense of "ownership" for long-term project sustainability.
- Transparent billing and cost monitoring will be practiced by the WUAs.
- An independent price regulatory agency will be established to supervise and oversee water pricing.

## Maharashtra: Mula scheme and Bhima scheme (Naik and Kalro 2000)

After management of two minor canals in Mula and Bhima, Maharashtra, India, was transferred to water user associations (WUAs), a survey was done to assess the impact on farmers.

In the Mula scheme, 82 percent of the farmers ranked water user associations (WUAs) as their first choice for supplying water. 74 percent of the farmers in the Bhima scheme indicated the same preference. This implies that WUAs generally have performed satisfactorily since the management transfer. In contrast, 69 percent and 36 percent of the farmers in the two control groups without the management transfer in Mula and Bhima, respectively indicate WUAs as their first choice. The differences in preferences were statistically significant. In the systems with WUAs, the majority of farmers (more than 75 percent) were willing to pay 25 percent higher water charges for the better services they received. The nontransferred canal in Bhima was the only one with the majority of farmers (60 percent) indicating government provision as their first choice. The preference for a private agency as water suppliers in both schemes was small (less than 5 percent). The survey also considered location in choosing farmers at the head, middle, and tail of the canal. The variations in preference in different locations were small. The major reasons farmers gave for selecting the WUA as their first choice were: assurance of water delivery and supply, less dispute among farmers, better maintenance, and lack of corruption.

*Highlights*

- The survey results indicate very high preferences for WUAs in places where management transfer has taken place. The survey also indicates a willingness to pay higher prices for better services. This empirical evidence demonstrates willingness to pay is linked to better service.
- The reasons given by farmers for choosing WUAs typically reflect their major concerns about inadequate irrigation water service. Therefore, these concerns should be the focal point of any irrigation management improvement project.

## INDONESIA

### Preliminary impact assessment, irrigation reform, Phase I, 1999–2002. (Alaerts 2003)

Water management in Indonesia has been decentralized and transferred from the central government to district governments and from the district governments to water user associations (WUAs), which are large, autonomous, legal entities. Decentralization was facilitated by the general administrative and fiscal decentralization that started in 2000. The local WUAs represent 2,000 to 5,000 farmers, who elect their own leaders who are responsible for water management and fee collection. Farmers participate in the selection, design, implementation, and supervision of any physical works. They can even engage in construction activities.

Before the reform, the central government financed almost all water projects. Now WUAs retain revenue from water charges to run the projects and organize farmers to contribute labor for routine operation and maintenance (O&M). District governments finance some infrastructure construction. During a transitional period, the national government still provides a subsidy to the district governments.

Among benefits from the program are:

- Overall transparency of government decisions and actions has improved substantially.
- WUAs are developing their skills, capacities, and internal governance quality. Also, WUAs are collecting increasing amounts of cash and labor from members.
- Overall productivity has improved due to better and more equitable water allocation. The irrigation water supply is more reliable and secure for farmers.

### Irrigation Subsector II (World Bank 1996)

The World Bank Irrigation Subsector II project in Indonesia strengthened cost recovery by updating areas registered for the rural land and building tax and by increasing the area covered and amount of irrigation service fees collected. Major achievements include a general acceptance by many communities in many districts that service fees should be paid and that WUAs should be responsible for collecting and paying this fee.

In the first season of 1994, a complete record of collection rates in the 35 districts monitored by the irrigation improvement project was available. Twenty districts had 100 percent collection rates, 4 had a record of more than 90 percent, and one had 80 percent. The other 10 districts had an average collection rate of 34 percent. Overall, the average amount collected was 70 percent, with 7 percent exempted and 23 percent unpaid.

Sustainability of schemes turned over to WUAs will depend on farmers' paying O&M costs and provincial water resource services' providing assistance for major or emergency repairs. Provinces are now responsible for all irrigation O&M. Irrigation service fees were successfully collected where WUAs were responsible for collecting the fees, users were confident that charges were determined fairly in consultation with farmer representatives, and the fees were used for maintaining a reliable irrigation water supply.

### Participatory Management (Bruns and Helmi 1996)

Irrigation management transfer in Indonesia started in 1987. It was based on policies including: gradual transfer of irrigation schemes smaller than 500 hectares to water user associations (WUAs), implementation of irrigation service fees (ISF) in systems larger than 500 hectares, and starting an on-farm water management development project combining training and subsidies to support improvements.

*Turn over in small systems*. A 1994 study in West Java and East Nusa Tenggara showed that, on average, yields increased one quarter ton per hectare per season after the management turnover. Water supplies and deliveries were also more reliable and equitable. However, about one quarter of sites still had poor returns, indicating that

further improvements were needed in water management. After the turnover, government support was still important, including, for example, an insurance program providing costs and cost sharing and capital for major repairs and improvements in case of natural disasters.

*Large systems with ISF*. WUAs are involved in collecting fees and in identifying priority needs for improving operation and management (O&M). Originally, service fees were to be used within the irrigation system where they were collected. However, it appears that, in many districts, use of service fees is not linked to a particular irrigation system, which makes the fees no different from an irrigation tax, without specific accountability and incentives. In addition, farmers rarely receive information about how service fees are being used.

*On-farm management development project.* Although implementation is still restricted mainly to pilot projects, it provides important lessons about improving the use of participatory management in irrigation systems. Practical training for farmers is provided through a series of two-year sessions. After the training, improvements were made in irrigation infrastructure. Each scheme received a government subsidy of $1,000, and farmers were expected to make up the difference by contributing labor, materials, and cash. This arrangement is financially transparent and should stimulate local contributions because governmental aid had clear limits on it from the very beginning. Farmers benefited mainly through improved water availability, which increased both production and farm income after the project. Lack of continuing support after the project is problematic because trained officials often returned to their normal jobs.

*Highlights*

- The most noticeable benefit of participatory management is the ability to involve farmers in planning, especially when preparing for a renovation or new construction. Participatory management evoked farmer interest and contributed to better project design. Joint walk-throughs with farmers were the single most effective technique for communication and cooperation because they gave farmers an opportunity to explain their top priorities for improving O&M.
- Another benefit of participatory management comes from involving farmers in cost sharing. In most turnover areas, farmers pay fees in cash or contribute labor and materials. Sharing costs give farmers strong grounds for insisting on high-quality construction and design that serves their needs. Farmers have an incentive to contribute in the hope that a large contribution may raise their status in the community or in the fear that failure to contribute might deprive them of needed assistance in the future.
- Farmers now have more equitable and timely water delivery. Previously, whoever had the most political or economic power received the water. Currently, WUA rules and regulations make for more equitable distribution of water.

## IRAN

### Zayandeh Rud Basin, Esfahan Province 2001 (Perry 2001)

In 2001, the water price for the gravity-fed surface irrigation system in the Zayandeh Rud Basin was $4/1,000m$^3$. This price allowed for nearly full recovery of operation and maintenance (O&M) costs. Water charges account for less than 10 percent of net agricultural revenue.

To significantly reduce demand, however, prices have to be raised to between $20 and $50/1,000m$^3$. Perry (2001) shows that the current water prices would likely have to be increased twentyfold before farmers would invest in field technologies to improve water use efficiency. At this high level, water charges will be equivalent to two-thirds of the gross farm revenue, which would be difficult to implement in practice. Perry (2001) suggests using water charges as a way of covering O&M costs fully and using rationing as a separate tool to restrict the amount of water used, instead of using high water prices.

One option Perry (2001) did not consider is use of an increasing block pricing system, with the first block equal to the quota set under the rationing. Another alternative would be to raise water rates and subsidize water-saving irrigation technologies, as is being done successfully in Yemen.

*Highlights*

- Sometimes the two objectives in designing irrigation pricing schemes—full cost recovery and reducing demand—cannot be achieved with just one price. However, an increasing block price can achieve both objectives.
- To deal with water shortages, rationing may be another effective way of reducing demand in the case of inelastic demand curves.

## MACEDONIA

### MACEDONIA (Cornish and Perry 2003)

Most schemes have reservoir storage but much of the irrigation infrastructure is in very poor condition. Most irrigation services are provided by one of the 20 Water Management Organizations (WMOs) which are overseen by a central Public Water Management Enterprise (PWME). Water charges are set to cover full O&M costs and capital depreciation. Charges are levied on an area basis. The charges include a 10 percent (it used to be 50 percent before 1998) fixed charge, calculated as 10 percent of predicted O&M and capital depreciation costs per hectare. The remaining 90 percent depends on the type of crop grown. Practices show that the fixed charges are too low since most of their expenditures on irrigation are fixed. The variable charge fluctuates greatly from season to season in this semi-humid climate. Under the Tikvesko Pole Kavardaci WMO income exceeds the expenditure on O&M by $ 41/ha, if expenditures on past debt and capital depreciation is excluded. If bad debt and capital depreciation are included, expenditure exceeds income by $ 165 /ha.

The collection rates were 42 percent in 2000, since collection enforcement has not been effective. In the past, defaulters were often brought to court, but as more and more people fail to pay, the court costs became too high for the WMOs, since it takes 3 to 5 years to process these cases. There are not many alternative means to sanction the defaulters unless they have a permanent source of income to confiscate, but the average farm holding is very small. An alternative is to suspend supply. However, this is not very practical since more than one farmer shares the same outlet, valve, or sprinkler system, which makes it difficult to shut off water to just one farmer.

*Highlights*

- Effective mechanisms for fee collection are equally important or even more important than designing the appropriate pricing policy. Lack of incentives for farmers to pay or penalties for failure to pay have resulted in serious collection problems.
- Alternatives need to be developed to solve the bad debt problem so that the WMOs can become financially sustainable.

## MEXICO

### Development of Water User Associations (Zekri and Easter 2003)

In 1990, after Mexico experienced serious problems with water delivery and fee collection, it began a program of establishing and turning over management and tradable water rights to water user associations (WUAs). By the end of 1997, 400 WUAs were operational, each controlling an average irrigated area of 7,600 ha. Surveys conducted in 6 percent of the districts showed that water use efficiency and maintenance had improved. Water charges went up in most districts due to the financial self-sufficiency target, increasing over 500 percent in some cases. Government subsidy, up to 1996, represented only 15 percent of the operation and maintenance (O&M)

costs in the transferred districts. If collected, the depreciation cost could not be efficiently used due to restrictive financial regulations prohibiting the use of accumulated funds. In addition, inflation and currency devaluation discourage holding such funds. Yet many WUA have made significant investments to repair or modernize their infrastructure using bank loans. The irrigation fees serve as a guarantee to the banks. More than 90 percent of farmers pay their assessed charges, primarily because they have to pay in advance for WUA services.

The success of WUAs is enhanced by the skills of a hired technical staff. In many districts in Mexico, WUAs assist their members in commercializing their outputs, obtaining inputs, and renting machinery. Eight limited-responsibility companies, which are federations of WUAs, were operating and providing services to WUAs by the end of 1996. These companies have expanded their services beyond maintenance and management of major infrastructure (Palacios 1999). The reforms focused on larger schemes and farms. The transfer in areas with smaller farms was started much later and is more problematic (Simas 2002). Commitment at the highest level of government is a notable reason for the positive Mexican experience.

*Highlights*

- Because farmers must pay in advance for water, they have a strong incentive to pay.
- WUAs' technically trained staff provides a wide range of services to members.

### ALTO RIO LERMA IRRIGATION DISTRICT (Kloezen Garces-Restrepo and Johnson 1997)

A two-year field research project started in 1995 in the Alto Rio Lerma Irrigation District studied the impact of irrigation management transfer. The study was based on data from 1982 to 1996, comprising 10 years of pre-transfer information and four years of post-transfer information.

The study found that:

- The transfer had very little impact on actual surface water allocation and distribution.
- Active farmer involvement in decisionmaking and control has increased managerial accountability. Farmers are particularly satisfied with the improved service provided by ditch tenders because farmers now have more control over the ditch tenders' work and rent-seeking behavior.
- The most positive impact has been the considerable improvement in maintenance, especially at lower system levels.
- Financial self-sufficiency increased from around 50 percent before the transfer to 120 percent in the post-transfer period. WUAs achieved 100 percent collection rates and also made the financial system more transparent.
- The transfer has not resulted in an increase in farmers' water costs. WUAs find it difficult to convince farmers that irrigation fees should be increased to keep up with inflation.

*Highlights*

- In the Mexican case, the irrigation management transfer did not come alone, but was part of a wider set of economic reforms.
- They created financial autonomy in the irrigation management as one of the key institutional changes.

## MOROCCO

### Morocco Water Sector Review (World Bank 1995)

The objective of water charges in Morocco is to recover 40 percent of the capital costs in addition to operation and maintenance (O&M) costs. The water charge is volumetric and the rate is high by international standards. The volume of water billed is typically 80 percent of available water, which suggests that the system loss in

delivery is relatively low.

The public irrigation schemes have reservoir storage, and water is distributed through overhead concrete channels with sophisticated division structures at control points. Farmers also rely heavily on private wells to provide additional, flexible water, which helps correct for some of the deficiencies in the public system.

### Tadla Scheme (Cornish and Perry 2003)

The collection rates in the Tadla scheme are between 70 and 80 percent on average. As the first and oldest irrigation project in Morocco, it costs much more to operate and maintain ($127/ha/yr, full costs of $150/ha/yr) than the Haouz project. Water charges account for 15 percent of net farm income.

Every farmer in Tadla has a "checkbook" to help track water consumption. At each water delivery, the farmer gives a "check" to the ditch rider, detailing the volume of water consumed, and keeps a copy for himself. Both the ditch rider and the farmer sign the monthly water delivery document to make sure there is no error in billing. The total water available for the season is defined in the checkbook, but the delivery schedule varies by individual farmer demands.

### Haouz Scheme (Cornish and Perry 2003)

Because Haouz is a relatively new project, the operation and maintenance (O&M) costs are as low as $30/ha/year, but the full cost including capital repayments and depreciation is $54/ha/yr, almost twice the O&M costs. Project-level data indicate that there are substantial subsidies because extensive "traditional" areas do not pay the charge and many farmers contribute labor for canal cleaning to reduce their payments to 40 percent of the designated charge. The collection rates range from 60 to 70 percent. For farmers paying full charges, the water fees are about 7 percent of net farm income.

Bills are prepared by the local Office Régional de Mise en Valeur Agricole (ORMVA), the organization responsible for agriculture development. If a farmer contests a bill, he can request a review, which is done jointly by the farmer, the ditch rider, other farmers using the same canal, and the president of the local water user association.

*Highlights*

- The "checkbook" approach combines rationing and flexibility. The total water available for the season is set in the checkbook. The delivery schedule can vary based on farmer demands.
- Both schemes are good examples of system transparency because farmers can verify water delivery and water charges.

## NEPAL

### NEPAL (Cornish and Perry 2003)

Most public irrigation schemes in Nepal are gravity-fed run-of-river diversions, but there are also some pumped irrigation schemes.

There are three different management types:

- Farmer managed schemes account for 70 percent of all irrigation projects and are concentrated in the hill areas. Farmers are responsible for all management activities. Government does not levy service fees on these systems.
- The public irrigation schemes are managed by the department of irrigation (DOI). Water fees from these systems are retained by the national treasury. In 1996–97, the average recovery rate of

operation and maintenance (O&M) costs was 1.3 percent. The fee collection rate was generally lower than 30 percent.

- In systems jointly managed by both local water user associations (WUAs) and DOI, collection rates were 58 percent. WUAs collect the fees, retaining part of the funds in proportion to their responsibility. The remaining funds are passed on to the national treasury. On average, water fees represent less than 2 percent of the O&M costs.

*Highlights*

In government irrigation systems, water charges are designed to cover O&M costs and in theory, some capital costs. In practice, they do neither.

## NIGER

### Niger, (Abernethy et al. 2000)

The government objective is to transfer responsibilities for irrigation operation and maintenance (O&M) to water user cooperatives. Pricing is designed to cover all O&M costs and part of the initial capital costs. From 1992 to 1996, the average seasonal fee in three rice-growing systems was $124/ha/season—high by international standards. The irrigation fees are equivalent to between 12 and 25 percent of gross crop value.

Fee collection rates are high, between 90 and 100 percent, but farmers are often quite late in paying their bills. The major objective of the water pricing system is to reduce water use, but it has not been successful because water charges are not related to water use or delivery. Farmers have little incentive to improve water use efficiency since it would not change what they have to pay. Conveyance losses run between 40 and 60 percent, and these losses are an extra cost that is divided among members of the user cooperative of perhaps a thousand members. Therefore, farmers have little incentive to provide labor for improving the system, considering that they receive only one thousandth of the potential benefit from reduced water loss. Irrigators in two of the three systems are dissatisfied since their cooperatives do not include them in the decisionmaking process.

*Highlights*

- Effective incentives are needed to encourage farmers to pay their water fees on time.
- An incentive system needs to be put into place that forces both farmers and service providers to bear some of the costs of their water losses.
- Participatory management needs to draw more farmers into the decisionmaking process.
- For the water fee to reduce water use effectively, it has to be related to water use (crop-area charge or volumetric charge)

## PAKISTAN

### Pakistan, 2001 (Ahmad 2002)

The large gravity flow irrigation schemes in Pakistan have not been successful in terms of either water use efficiency or cost recovery. Area and crop-based flat rates have not encouraged efficiency in water use because neither is related to actual water use. The charge in 2001 per acre-inch of water was Rs. 2.04 for rice, Rs. 3.09 for wheat, and Rs. 2.36 for sugarcane. Rational producers maximize water use, even though water may be scarce. The variations in water charges by crop imply that irrigation water is subsidized more for certain crops. Experiments show that using different irrigation methods can improve water use efficiency. However, because there is no relation between the quantity of water used and water charges, farmers have no incentive to try better technology.

The overall efficiency of the Indus irrigation system has been estimated at only 35 to 40 percent. Fee collections

are inadequate due to ineffective enforcement of charges and poor irrigation services. Thus, revenue collections financed only 30 to 35 percent of the operation and maintenance (O&M) expenditure of the irrigation department in 1998–99. Continued inadequate expenditure for O&M will cause further water loss and inefficiency. The revenue from water charges is commingled in the provincial treasury with other tax revenues, further reducing the incentives to pay water charges. This means that there is no relation between funds allocated for project O&M and fees paid by farmers.

*Highlights*

- There is no link between water charges and services provided since the revenue collected from water charges does not go to improve the irrigation system. Thus, farmers have little economic incentive to pay water charges.
- In addition, service providers have no incentives to collect fees.
- Because the above crop-based water charges were designed to ignore differences in water use by crop, they do not give farmers an economic incentive to grow water-efficient crops.

### SINDH PROVINCE (Cornish and Perry 2003)

Sindh province, located along the lower Indus river, is the second largest province in Pakistan. Wheat, rice, and cotton are the three dominant crops in that area. The irrigation management system is undergoing reform, including changes to the pricing system, because the government subsidies can no longer sustain the required operation and maintenance (O&M) expenses.

The major water source for irrigation is through barrages. Sindh also has serious drainage and groundwater salinity problems. Located at the tail-end of the Indus irrigation system, the province often does not get its agreed-on share of water. There are also enormous management problems in the system. The Irrigation and Power Department is in charge of irrigation water in Sindh, but its performance has not been supervised. It does not generate its own revenue or collect water charges.

An assessment of ability to pay for the O&M costs was made in 1995. The result suggested that, despite the relatively low net farm income, farmers can pay for irrigation services, and the current water fee accounts for only 2 percent of the net farm income. Collection rates are low (less than 30 percent) because farmers are not willing to pay due to the corruption among irrigation officials, poor service quality, and lack of system transparency.

In 1997, a major reform program took place, and a new agency, the Sindh Irrigation and Drainage Authority (SIDA), was established. Its goal was to achieve financial self-sufficiency, defined as paying full O&M costs in a 10-year period. O&M responsibilities were transferred to farmer organizations that serve an average area of 3,000 ha.

Water prices, determined by the provincial government, are regarded as a tax to be paid as a single bill along with land and other taxes. The water tax is area based and differentiated by crop and by irrigation system. Even assuming 100 percent fee collection, current charges are still too low to cover O&M costs.

## PHILIPPINES

### Laur Project (Coward 1980)

An important aspect of user participation is full farmer involvement in the decision-making process. For new projects or rehabilitation, farmers should be consulted before the projects begin. The Laur project of the National Irrigation Administration (NIA) in the Philippines is a good illustration of active farmer involvement. NIA assisted in the rehabilitation of a community system, and local farmers actively participated in the whole

process. They assisted in the preconstruction engineering survey, commented on the initial construction designs, and maintained a careful record of construction expenditures. The water user association was particularly serious about controlling expenditures because it had to repay a loan to NIA for the work. Farmer supervision made the financial system transparent and prevented any corruption by irrigation officials. The benefits of this active user involvement are: (1) design and construction fit specific local needs because the project was done based on farmers' suggestions; (2) local commitment to the project was created; (3) because the project was constructed to serve farmers' needs, the farmers were more willing to pay for the improved services.

*Highlights*

- This case provides evidence that user participation is important, especially when it involves farmers in the decision-making process in advance of project rehabilitation or construction.
- It shows that user participation can improve system transparency and increase farmers' willingness to pay for the services.

## SPAIN

### Mula Area Murcia (Del Amor Garcia 2000)

As part of an irrigation improvement project, a water teller system was installed. Each farmer receives an annual share of water in cubic meters, his own water account, and a report of the water remaining after each irrigation. Farmers can also use the water teller to program the opening or closing of their irrigation gates and even program the release of fertilizer into their fields. The water teller is located outside community headquarters.

Automation of the irrigation system in the Mula Area was accompanied by major infrastructure investments, including water storage and a pressure irrigation network. The traditional system, which is being modernized, dates back to the Muslim period of the 9th and 10th centuries. Before the modernization, the system was characterized by high water losses and fragmented land holdings in which 68 percent of the fields were smaller than one hectare. The systems modernization and automation resulted in an 88 percent reduction in water losses from the distribution system, a decline in losses from 1.2 million $m^3$ in 1987 to 0.14 million $m^3$ in 1998.

*Highlights*

- The automation system has merits similar to the integrated circuit card system in Shangdong, China. It provides effective enforcement of fee collection and also gives farmers full control over their water use.
- No information was provided concerning water fees or fee collection rates.

### Siurana-Riudecanyes (Tarrech et al. 1999)

The Siurana-Riudecanyes irrigation district in Tarragona province delivers approximately 6 million $m^3$ of water each year. The hydraulic infrastructure consists of two dams, an inter-basin channel, two main distribution channels, and corresponding networks. It supplies water for the farmers in the irrigation district and water for municipal uses in the city of Reus.

The local residents have a long history of raising funds from both public and private sources. Contributions from direct beneficiaries (farmers, municipal users from the city of Reus, and other users) were raised by issuing water rights for the added water capacity in the system. Operation and maintenance (O&M) costs have always been covered by the water users through their contribution to the water user association (WUA)[11]. Since 1972, the WUA has operated with enough funds to support further improvements in the infrastructure.

The right to use water is obtained through regional water authorities. Water titles are distributed to association

members based on their contribution to construction and the irrigable land owned. Water titles have always been traded among the WUA members, including farmers and municipal users. Both long-term and temporary transactions take place in the water market. In 1982, an official exchange, administrated by the WUA, was formed, which significantly reduced water price volatility and made the exchange more transparent. A system of bonuses and incentives was also established for the WUA workers to minimize water loss and reduce O&M costs. All the workers are hired from private companies, which equip the workers well for their jobs. For example, they have a radio-telephone system so that a prompt response is guaranteed to any emergency in the network.

The WUA represents a central force in the system with active user participation, transparency in its functions, and flexibility to adapt to specific circumstances. The city council of Reus also has had a significant impact on the water market. It provided a large part of the funding for the original work (50 percent contribution, another 40 percent as a loan to be repaid by the direct beneficiaries) and played an active role in water management. In addition, direct beneficiaries contributed 10 percent of the funding.

*Highlights*

- This is a good example of achieving financial autonomy through costs sharing among different water system beneficiaries, particularly when a new project is to be built.
- Water rights, in this case, are closely tied to financial contribution, which helps create a sense of ownership and achieve cost recovery.
- The water user association plays an important role in the system

## SRI LANKA

### SRI LANKA (Samad and Vermillion 1998)

From 1988 to 1998, the government of Sri Lanka formally implemented a policy of transferring to farmer organizations (FOs) full responsibility for operating and maintaining irrigation facilities below the head of medium-size and major schemes' distributional canal. The FOs are organized along hydrologic boundaries.

Government expenditure on irrigation began to decline before the irrigation management transfer (IMT). Expenditures dropped in both non-IMT schemes and in schemes where transfer had occurred. The reforms have not substantially increased farmers' irrigation costs. Farmers generally make fewer direct payments (in cash and kind), but contribute more labor for canal maintenance. The survey done in Hakwatuna Oya and Nachchaduwa showed that the majority (90 percent) of farmers in both schemes claimed that there was no cash fee on irrigation before turnover. After transfer of O&M functions to FOs, some of the organizations charged a modest fee for canal maintenance. The survey results showed that a minority of farmers (23 percent in Hakwatuna Oya and 16 percent in Nachchaduwa) paid the maintenance fee. In both schemes, farmers' irrigation cost is primarily in contributions of family labor for canal maintenance and payments in kind (a half-bushel or 11 kgs of paddy per acre) to the person employed by the FO to distribute water.

In Nachchaduwa, nearly 60 percent of all farmers interviewed felt that the condition of the canal system was worse after management transfer. This implies extensive farmer dissatisfaction with the rehabilitation, which was done without farmer participation. Also, the infrastructure inspections revealed a serious under-investment in maintenance. Neither IMT nor rehabilitation alone resulted in significant improvements in agricultural production. However, in schemes where both management transfer and rehabilitation occurred, significant increases were found in agricultural productivity and economic returns.

Senior Irrigation Engineer N. Fernando from the World Bank, has reported significant improvements in communication between farmers and irrigation since the management transfer project, including: farmer participation and decisionmaking in O&M, seasonal crop planning, water allocation and management, and

rehabilitation activities. All major and medium-size irrigation schemes now have project management committees chaired and managed by farmers[12].

*Highlights*

- Participatory management with the aim of full cost recovery will not necessarily increase water charges since farmers have the option of contributing more labor for O&M rather than cash.
- Participation should start before project rehabilitation is considered so that farmers can be involved in the decisionmaking process regarding the rehabilitation.
- Sometimes a combination of changes must be made before a project can operate effectively. In this case, rehabilitation and management transfer needed to occur at the same time.

## UNITED STATES

### SAN JOAQUIN VALLEY, CALIFORNIA (Schoengold et al. 2004)

An agricultural water demand model based on an episode of rate reform was estimated by using a unique panel data set from California's San Joaquin Valley. There were three major findings: (1) Price changes do reduce the demand for irrigation water. The estimated own-price elasticity of agricultural water demand was in the range [–0.275 to –0.415], which is higher than indicated in previous studies. (2) Price changes influence the choice of irrigation technology and crops. The demand elasticity can be decomposed into direct effects and indirect effects of demand reduction in response to price increases. The study showed that indirect elasticities were all negative and significantly different from zero, meaning that a change in the price of water induces water-conserving activities. On the other hand, the indirect effects were much smaller than direct effects (indirect effects account for 17 percent and direct effects account for the rest). This can be explained by the fact that water price influences technology choices but it was not the only determinant of technology improvement. Similarly, the water price had a relatively small influence on crop choice because the price of water is often a small share of the cost of agricultural production. (3) Water use can be reduced significantly by switching irrigation technology from gravity to drip or sprinkler in most crops, including: citrus, grapes, deciduous tree crops, and truck crops. Of these, citrus shows the most striking changes. When irrigation technology switches from gravity to drip irrigation, efficiency (water use per acre) increases by about 50 percent.

*Highlights*

This study illustrates how water use efficiency can be improved through pricing incentives. In addition, it shows how different prices for different crop and technology can induce technology and crop changes.

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[1] "Price," "fee," and "charges" are used interchangeably in this report. In all cases, we mean the amount of money asked or given for a good or service. A price, fee, or charge for water is money asked or given for the water itself or the service of delivering the water, or both. This is in contrast to the term "tariff," which means any list or scale of prices or charges, not the specific price or charge itself (Webster's Dictionary).

[2] Nihal Fernando (Senior Rural Development Specialist, World Bank), in discussion with the author.

[3] 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.

[4] 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.

[5] All dollar amounts cited in this paper are U.S. dollars.

[6] Ariel Dinar (Lead Economist, Agriculture and Rural Development, World Bank), in discussion with the author.

[7] 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.

[8] An inelastic demand curve has a steep slope where the responding change in quantities demanded is smaller than the price change. Demand elasticity = $\% \Delta Q / \% \Delta P$ (percent change in quantity relative to percent change in price).

[9] Manuel Contijoch (Senior Water Resources Specialist, World Bank), in discussion with the author.

[10] This would generally be the O&M charge for the season but, in some more advanced systems, it would be the cost of the volume of water delivered at each irrigation.

[11] An irrigation subscriber association is used instead of the more common water user association but it performs the same functions

[12] Nihal Fernando (Senior Rural Development Specialist, World Bank), in discussion with the author.