Sustainable irrigation and the role of economic instruments and their supporting institutions

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Abstract

This paper identifies a number of institutions that are critical for the financial sustainability of irrigation projects. The framework of analysis is based on Williamson's four-levels of institutions (Williamson, O.E., The new institutional economics: taking stock, looking ahead, *J. of Economic Literature*, **38 (September)**, pp. 595–613, 2000) which are used to highlight the importance of institutions and the problems that arise when implementing institutional change. Examples are provided of institutional reforms and changes that have helped different countries raise both cost recovery and collection rates. A key objective in designing water instruments is to provide farmers and managers assurance regarding the actions of others in the system. Without the appropriate institutions, it is difficult to effectively use economic instruments such as water prices, taxes, or markets to improve the financial sustainability of irrigation projects.

Keywords: cost recovery, economic instruments, water pricing, institutional arrangements, financial sustainability.

1 Introduction

Strong finances to support and maintain both irrigation and its associated drainage system are essential for sustainable irrigation. Historically, the lack of adequate finances has resulted in inadequate system operation and maintenance (O&M) and caused many irrigation systems to be built with inadequate control structures and, in many cases, no facilities for drainage. The end result has been projects that decline rapidly in their ability to provide adequate and timely water delivery. In a few years these same projects also face declining irrigated acreage as water logging and salinity problems force land out of production. Thus, once it has been determined that it is appropriate to build an irrigation system of a

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given size and design, we need to determine how to appropriately fund the project over time. The key questions we will try to address in this paper are 1) how much of the financing can reasonably come from water users and 2) how this share can be effectively collected from water users on a sustainable basis.

To set up a system that will provide sustainable funds for irrigation and the necessary drainage will involve establishing effective institutional arrangements to support efforts to collect water charges from users. Institutions can be thought of as "rules of the game" while the "players or groups of players" are the organizations, firms, and individuals [2]. Institutions are important in structuring incentives as well as providing order and predictability, particularly regarding the actions of others. Livingston and Garrido [3] argue that institutions are important for effective water management. "Institutional arrangements are critical in creating incentives because they: 1) define who has access to water resources, 2) establish the range of (legal) options open to legitimate water users, and 3) determine who can claim income from water use and who will bear the costs of water use." Effective institutional arrangements will need to be in place to have sustainable finances for irrigation and to sustain the irrigation system.

The remainder of the paper will start with a brief description of the institutional framework used in the analysis. This is followed by a section concerning fee collection and the determination of what share users will pay. Next, is a discussion of water pricing mechanisms, followed by examples of projects where new institutional arrangements have helped improve cost recovery and project sustainability. This leads to a section that suggests how institutions can be combined to provide a stable source of funding for O&M. The final section provides a brief summary and conclusion.

2 Institutional setting

A good way to think about institutions and how they influence outcomes is to use Williamson's [1] four levels of nested institutions. They include, first, the informal institutions such as social norms, customs, religion, etc., which change very slowly. These norms and customs act as constraints to what you can do at the other three levels. For example, strongly held customs or mores regarding free access to water may have a big impact on who gets water and how much they pay. It also may prevent, or make it difficult, to introduce private property rights for water use and to introduce water markets.

The second level of institutions is the formal rules of the game or the policies that guide water use and allocation. To make changes at this level will usually take several years to over a decade. For example, if you want to establish a water market, one of the key changes needed is to establish and allocate water rights, or water use rights, to individual water users. Such changes in property rights, laws, or policy can be difficult to make. For existing systems they will only be changed after a number of years of hard negotiating and bargaining or a significant change in a country's economic policy that favors markets, as happened in Chile [4]. The content of water policies and laws are addressed at this level including whether or not water can be sold separately from land and for

what uses. In terms of financing irrigation systems, it is at this level where water policies are crafted that specify who pays for water projects and their operation.

Level three focuses on governance structures for transactions. At this level decisions are made about the mechanism for allocating water, e.g., hierarchy vs. markets or contracts. There will also be concerns about mechanisms for enforcing water allocations and for resolving conflicts that are likely to arise. The complexity of the governance structures will increase as water scarcity, its value, and conflicts increase. Birner and Wittmer [5] argue that the most efficient form of governance and its structure and complexity will depend on the characteristics of the resource, e.g., water scarcity and the social and political characteristics of a country.

The fourth level of institutions falls in the domain of neoclassical economics where governance is ignored and the emphasis is on the firm as a production unit. Institutions are generally assumed to be fixed and treated as exogenous constraints. At this stage questions occur regarding the firm's ability to pay for water and how water charges or fees may change water use or the adaption of new water-saving technology. Level-four institutions are very important in determining the actual level of water charges paid by individual water users and the services they are provided by the irrigation system.

3 Financial failures in public irrigation

Traditionally, both developed and developing countries have found it difficult to establish a sustainable source of funding for operating and maintaining their irrigation projects. In his 1995 study, Jones [6] illustrates how cost recovery and charges for irrigation water have been a problem for decades. In many countries less than twenty percent of the cost of irrigation projects has been recovered from water users [7]. This is the result of poor rates of collection combined with relatively low water fees. The end result has been a large public subsidy for water users, particularly irrigated farms.

There are many reasons for this poor record of cost recovery in public irrigation projects. Although the reasons vary among countries and individual projects, Easter and Liu [7] list some of the most important ranging from: "1) no link between fees collected and funds allocated to a given irrigation project, and 2) lack of farmer participation in planning and management of projects, …. to 4) poor delivery of water services (timing, duration, and quantity are inadequate), …. and 9) corruption among irrigation officials and those collecting water charges." They go on to make it clear that the basic underlying causes for the poor cost recovery stem from "the collective good nature of water projects, combined with open access to water resources, the principal-agent problems and rent seeking activities of irrigation officials. It also can be thought of as an assurance problem: assurance for managers concerning what water users will do and assurance for water users concerning what water managers and their staff will actually do as opposed to what they say they will or can do given the existing project design and technology [8]."

Another part of the problem is that we do not think about sustainable finances early enough in a project's development. During the planning stage, we need to

decide on the source of finances to effectively operate and maintain the project once it is built. As part of this financial planning we need to determine to what extent water users should be the major source of funding and how the cost will be allocated among the various users, e.g., farmers, hydropower users, domestic water users, commercial and industrial water users, and those protected from floods. The allocation of costs is an important issue because many of the water projects are multipurpose, particularly in Asia where 90% of the dams for irrigation are multipurpose. There is also a good argument to be made that some of the costs should be allocated to consumers who benefit from lower food costs, particularly in developing countries. In fact, if commodity markets are poorly developed, the increased production may mean farmers receive only modest increases in net returns because of the drop in commodity prices caused by increased production in the irrigated area. Yet many times decisions have been made to allocate most of the cost to farmers, since they receive much of the water. A better cost allocation might be to allocate costs based on direct project benefits or on direct and indirect project benefits. Easter and Liu [7] show it makes a significant difference. For example, if the costs to be recovered are allocated based on water delivered in the Sriram Sagar project in India, farmers must pay 95% of the costs. If the costs are allocated based on direct benefits, farmers have to pay 88% of the costs [9]. The percentage of cost allocated to farmers would drop even more if the allocation was based on direct and indirect benefits, probably to something less than 75% of the costs.

Once a reasonable allocation of costs has been decided on for farmers, the next question is: what economic instruments can be used to effectively collect the water fees necessary to cover the allocated costs? The other important question is: have the critical institutional arrangements been put in place, at the planning stage, that will make the fee collection effective?

4 Economic instruments

The approach one selects for charging the water users will depend a lot on what institutions already exist and the size of the project, both in terms of hectares irrigated and the numbers of farmers actually served. For large projects in developing countries with limited farmer participation, area-irrigated based fees have generally been used. The problem is that this means there is no relationship between what the farmer pays and the amount of water he or she receives. This also means that the water charges will have no effect on water used. A better alternative, maybe, is to vary the charge by type of crop grown with higher per hectare charges for crops such as rice and sugarcane that use more water. In some cases the water charge might vary based on irrigation technology used. If farmers adopted improved irrigation technology such as sprinkler irrigation, which distributes water more uniformly across the field than flood irrigation and uses less per hectare, they would be charged a lower water fee per hectare.

For smaller projects, particularly in more developed countries that face a high level of water scarcity, we need to be moving toward volumetric-based water charges. With the improvements in technology the argument that water use or

delivery is hard to measure is no longer very convincing. The big issue may be cost, but even this may not be a true constraint given the new technology now available [10]. Volumetric-based water charges have two clear advantages. First, farmers know how much water they receive and that the charge will be based on this quantity. Second, it gives farmers an incentive to not over irrigate and to conserve water. This will require not only water measurement but also infrastructure and staff to effectively control water deliveries.

Block water charges can also be used with volumetric-based fees as a means to provide a minimum amount of water at low rates while charging much higher rates for use exceeding a set volume of water per hectare. This type of charge has several benefits. First, it gives irrigation managers at least three instruments to change cost recovery: the levels of the first and second block charges and the quantity at which the second block charge starts (e.g., 3,000 m^3/ha vs. 4,000 m^3/ha.). Second, the second block charge or even a third block charge can be set at the marginal cost of developing new water supplies, which will encourage farmers to conserve water. In addition, this higher charge will have less of an adverse impact on farmers' income since it is only charged for the units of water used beyond the first block.

A two-part charge can be used, combining volumetric charges with a fixed charge. Such a system of charges may be necessary if water availability varies a lot from season to season and/or year to year. The fixed charge allows water managers to obtain a basic amount of funding even in years of low water supplies when many farmers do not receive much water. If the water charges were based only on volumetric charges, then in the years of low supplies the volumetric charges might have to be very high to cover costs. This method of charging for water also recognizes that there is a large fixed component in operation and maintenance costs (O&M), which does not depend on the amount of water delivered. These costs need to be paid even when no water is delivered.

A final option would be to introduce a water market. This could be in addition to the water charges for O&M. Water trading would improve allocation efficiency by increasing water's value to farmers and shifting water to its highest valued uses. In turn, this would increase the user's ability to pay since water would be used to produce higher valued crops. As discussed above, to introduce markets a number of key institutions need to be in place, including a water law that allows the sale of water independent of land and a system to resolve disputes over water rights and third-party effects.

5 Institutions to improve cost recovery

One good measure of the success of an irrigation system in sustaining its financial base is to look at the collection rate from its water users. In many systems only 10 to 60% of the users pay their fees [11]. Table 1 lists eight irrigation projects that have been quite successful in obtaining high rates of fee collection with half reaching 100%, and three reporting substantial water savings. Using these projects as examples of successes in sustaining finances, what institutions were important in their success? Several key institutional

arrangements have helped these systems move closer to financial sustainability. First, they needed to be able to legally establish water management entities that were, at least partially, financially autonomous from government. This helped establish an important set of incentives for management that fostered improved collection rates. A second important law was needed that allowed users to organize into water user associations (WUAs) and participate in the management of the irrigation system. If possible, they should have some authority to allocate water among users and authority to tax. Through active participation water users establish a closer working relationship with management, which helps increase system transparency and accountability which, in turn, improves users' willingness to pay water fees. Too many times WUAs have been established and given only responsibilities such as contributing "free" labor but no authority. This is why a number of WUAs have not improved the sustainability of their irrigation systems.

Table 1: Factors influencing fee collection rates.

Cases	Financial autonomy	Incentives to collect	Incentives to pay	User participation	Collection rate (percent)
Awati, China*	Yes	Yes	Yes	Yes	98
Bayi ID, China	Yes	Yes	Yes	Yes	100
Nanyao ID China	Yes	Yes	N.A.	Yes	95
Shangdong China*	N.A.	N.A.	Yes	N.A.	100
Yangtze Basin, China*	Yes	N.A.	Yes	Yes	N.A.
Gujarat, India	Yes	Yes	Yes	Yes	100
Haryana, India	Partly	N.A.	Yes	Yes	85–95
Mexico	Yes	N.A.	Yes	Yes	90
Alto Rio Lerma, Mexico	Yes	Yes	Yes	Yes	100

N.A., Not available. *These systems reported substantial water savings. Source: [7].

Why is it that establishing financial autonomy and active user participation improves the sustainability of irrigation projects both in terms of their operation but also their finances? Financial autonomy changes several important incentives. First, the fees collected from users are used for the project and do not go back to the state or federal treasury where they would be commingled with other tax returns. In other words, if you do not pay your water fees, it will have an impact on "your" project's ability to deliver water. That is not the case in many countries where the revenue arm of the government collects or tries to collect the water charges, which then go to the federal or state treasury. In such cases, farmers do not see any relationship between what they pay and the services they get from their irrigation system.

The Yangtze Basin Water Resource (Yangtze) project in China is a good example of an effective water management entity that is financially autonomous.

It also requires direct involvement of WUAs in water management decisions. This has increased crop yields and saved significant amounts of water, 1.2 million m^3 annually in each WUA. Yet they do not report how much fee collection rates have been improved [12].

Financial autonomy also means that government subsidies are not available and they must rely on fees collected from users to cover O&M costs. This is a second important incentive. Now the water management entity wants to create conditions that result in high collection rates from the water users. As a result management uses several different strategies. One is to use strictly enforced penalties for those who default on payment. For example, in the Bayi Irrigation District, irrigation water is denied those who defaulted [13]. A second strategy is for the management entity to give awards or penalties to encourage staff to achieve higher rates of collection. In Awati, China, staff salaries are dependent on water charges and collection rates have reached 98% [14]. The staff in Bayi Irrigation District receives rewards for turning in collected fees by a deadline, but is fined for late payments [13].

In terms of participation, it is beneficial to get users involved early in the process of project design and building. This is particularly true for rehabilitation projects that farmers are expected to repay the costs or contribute labor. This makes the decision making process more transparent and increases users' willingness to pay for the improvements. The Laur Project in the Philippines provides one example where the WUA were able to review the rehabilitation proposal before it was implemented. Coward [15] found that this improved the project design and the users' willingness to pay.

Finally, a water management entity that is financially autonomous has an incentive to provide users a good service. This will not only give users more reason to pay their fees, it should also increase their ability to pay. Better irrigation service should result in increased yields as it did in the Yangtze Project. This should increase farmers' incomes and ability to pay for the water.

Another more dramatic way to increase user participation and create management incentives has been irrigation management transfer (IMT) to the users. This strategy has had mixed results partly because of what management responsibilities were actually transferred and the condition of the infrastructure at the time of the transfer. Several of the transfers have gone well [16] while others have not. As Zekri and Easter [17] found, IMT tend to be "successful where farmers had their water rights established, farms are medium and large scale with good access to markets and the government had a strong willingness to empower users." In contrast, programs that emphasized only farmer participation were not very successful. Farmers need to perceive some clear benefits from participation and taking over system management.

6 Supporting institutions

Too many times we have focused only on the technical or engineering side of irrigation projects. Of course, the engineering aspects of a project are important and in a technical sense determine which farms can be irrigated. What has been left out are the institutional arrangements that are needed to determine who actually has access to the irrigation, who can claim income from the water, and

who will bear the cost of water use [3]. Some of the institutions that will be critical in the sustainable financing of irrigation project were discussed above. These include the legal institutions that allow financially autonomous water management entities to be established and the organization of effective WUAs. It is also becoming clearer that water users need some type of water rights that will give them assurance regarding when and how much water they will receive during the crop season. These might be outright water rights that can be traded either permanently or temporarily, or water use rights that have a set lifespan, e.g., 30 to 99 years. Another option which establishes the right incentives is a water contract between the farmers and the water management entity that specifies the amount and timing of water to be delivered to farmers. This was one of the keys to the success of the improved irrigation project in Katepurna, India where they have saved 7.7 million m^3 of water annually and expanded the area irrigated by 80% [18]. Over-irrigation in the wet season was greatly reduced since farmers no longer had to try to store water in their soil for the dry season. They now have a contract assuring them water for the dry season.

As part of an institutional arrangement that establishes farmers' rights to water, it must be clear how the rights will be allocated. When they established water rights in Chile in 1981, the consumptive use rights were allocated based on past water use, which was fairly equitable since most irrigated land holdings were relatively small, 50 ha. or less [4]. It is a more difficult question for new projects. If the area to be irrigated is already farmed, then past land ownership will likely be a key factor in the water rights allocation. Another option would be for the state to reserve some of the water rights and auction off the rest for commercial use and irrigation. If the water rights to a new project are going to be given to farmers, as they were in Chile, then one option would be to limit the area one farmer can irrigate. For example, the U.S. Reclamation Act that authorized federal funds to develop irrigation in the western U.S., limited the area one individual could irrigate to just under 65 ha. However, the limit has proved difficult to enforce, particularly in California, even after it was raised six fold in the 1980s [19].

You also need an effective local system for enforcing water use rules and water rights. In more developed countries this might be the court system, a water agency, a WUA, or some combination of the three. In less developed countries the village leadership is likely to play a much larger role. In some cases the village leadership makes it difficult to establish other methods of managing water by essentially running any WUA.

Another important institutional arrangement that needs to be in place to improve fee collection is a mechanism to make the process of setting water charges more transparent. If the charges are based on the cost of O&M, as they are in many cases, then users need to know how costs are calculated and what costs are to be included. This knowledge can help reduce the fear among users that the fees will be used just to enrich water managers and their families.

Finally, an institutional arrangement is needed that allows a council or review board to be set up that can review the record of farmers who are not paying their water fees. This can serve two important purposes. First, it can determine if

there are circumstances that make it difficult for some farmers to pay their fees, such as crop failure. In such cases the council can then decide to forgive some or all of the farmer's delinquent fees. Second, they can use the review as a time to make it public in the villages who is not paying their water fees.

7 Conclusion

This paper emphasizes the importance of institutional arrangements in sustainable irrigation and focuses on those institutions that are critical to financial sustainability. Williamson's [1] four-levels of institutions are used to show how institutional arrangements at these different levels can guide water use and facilitate the process of determining who should pay for the water. A well-constructed irrigation system only assures that the water can be delivered, not that it will be used effectively, or that it will be financially sustainable.

Based on past projects that have been successful in maintaining high rates of fee collection from their users, several institutional arrangements appear to be critical. One is for the management or operating entity to be financially autonomous from government. This creates a set of incentives that focuses management's attention on providing good service, accountability and the importance of fee collection. If the farmers are going to pay for the irrigation, they want assurance that they will receive dependable and timely service. One set of institutional arrangements that increase these assurances for farmers are those necessary to create water rights or water-use rights. There is also the possibility that similar assurances can be achieved through contracts between management and users regarding water delivery and payment schedules. The trick is to make these contracts binding on all parties.

A final set of institutional arrangements that will be important in maintaining high levels of fee collection are those that improve communication between management and users. Here WUAs that are given authority along with responsibility for management can play a key role. They can also be important in making the process of determining and setting water charges more transparent and in helping establish mechanisms to deal with farmers who default.

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