V Irrigation Management Under Resource Scarcity

> Even thinking about water is difficult; keeping track of it can be impossible. It flows, drips, seeps and percolates, evaporates, condenses, freezes and transpires. It combines in compounds; it forms part of living things; it is in the soil, in plants and in the air. It is brought unpredictably in and out of environments by the weather, falling in rain or hail or snow, or settling as dew. Nothing is constant. Flows change. Movements from one place or medium to another are hard to put numbers on. Water for irrigation is difficult to handle: it has to be captured, stored, transported and delivered to a myriad of small fields and applied for crops to grow. Water is at once ubiquitous and elusive, a maddening compound which mocks measurement.
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> – Robert Chambers (1988)

INTRODUCTION

The control of water has been central to Asian agricultural development. Irrigation accounts for 70–80 percent of Asian water diversion. Heavily subsidized irrigation investment claimed by far the largest share of public investment in agriculture during the green revolution. But water is also a basic human need, an essential input in most industrial processes, a resource for the provision of electricity, and an essential element in the conservation of desirable natural environments. The past decade has seen increasing concerns about the sustainability of the costly physical infrastructure for water's control and about the emerging scarcity of water due to growing demand for its competing uses. These concerns have led in turn to the rethinking and retooling of the roles of the State in irrigation development and management.

Two somewhat contrary thrusts have emerged. On the one hand, the sustainability issue, bolstered by recent constraints on State financing capacity, has prompted a variety of approaches to devolve or privatize the development, or at least the management, of individual schemes. On the other hand, at the "macro" level of the water basin, the increasing scarcity of water is likely to require enhanced State regulatory roles in allocating and ensuring the quality of water allocation and in resolving conflicts over its use. Irrigated agriculture will tend increasingly to be a residual claimant of water and so will come under increasing pressure to economize.

This chapter concentrates on irrigation because of the enormous scale of past investment and because of its importance to agricultural growth in most of Asia during the past two decades.[1] The first section deals with the sustainable development of the relatively small-scale irrigation systems located primarily in Asia's upper watersheds. The second section covers the more complicated development and management of large-scale irrigation in the lowlands, dealing also with groundwater irrigation in light of its dramatic recent growth. The third section deals with water management issues in the water basin as a whole, examining alternative responses to scarcity, the problems of water-use efficiency and watershed management, and irrigation's role in the context of broader water resources policy. The final section sums up by synthesizing the medium-term issues for public policy.

[1] Rural nonagricultural water use is covered in the discussion of rural social services in Chapter VII. Water surfeits requiring flood-control infrastructure are considered only in passing in the present discussion, as such large works have traditionally fallen entirely within the domain of the State in Asia and will largely remain so during the medium term.

THE LANDSCAPES OF IRRIGATION MANAGEMENT

The water basin provides the macro perspective on water-management issues. A water basin can be regarded as an integrated unit because of the interdependence of water supply at its different points. The basin also usually forms a more or less distinct unit because the transfer of water between basins is expensive. Among the different basins, and within a basin, there can exist different types of irrigation systems and institutions. Taking a broad historical perspective, Wade (1995) hypothesizes that these systems and institutions depend on four ecological factors: population density, irrigation requirements, temperature constraints on crop-growing periods, and topography. For the present purposes, topography is the primary factor determining the scale of the infrastructure, which in turn determines the relative scope for public- and private-sector involvement in irrigation development.

There are generally two broad types of landscape within each water basin. The first is the upper basin, where small-scale gravity irrigation systems are normally designed and built, usually, at least initially, by communities of farmers themselves. Included in this category are the lower reaches of the small water basins, where the communities sometimes operate irrigation as well. The second type of landscape encompasses the lower floodplains of large river systems,[2] where large-scale irrigation systems are invariably designed and built by the State. Groundwater constitutes an alternative source of water supply in the lower reaches of the water basins, so it will be considered along with the lower floodplains.

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[2] Trung (1978) suggests a different taxonomy, distinguishing the river systems of mainland Asia from those of Asia's islands. Many water basins in island Asia are small and therefore correspond to the first type discussed in this chapter. However, most of the larger water basins in mainland Asia also contain the first type of landscape, e.g., in the upper reaches of the Mekong basin in the southern PRC, Lao PDR, Myanmar, and Thailand.

Upper- Basin and Small-Floodplain Irrigation

Evolution and Organizational Characteristics of Small-Scale Schemes

Traditional societies in Asia, both on the mainland and on islands, have practiced small-scale irrigation for millennia, well before their modernization. Because of this historical origin, communities played a major role in design and construction and, in some cases, still play a very active role in the operations and maintenance (O&M) of the infrastructure. In many cases, however, their role has been progressively reduced, with the State taking over many of the traditional functions of these communities. The first stage of the State's intrusion into these irrigation systems has been upgrading the facilities.

The food and energy crises of 1972–74 provided the impetus to intensify agriculture, while the green revolution provided a technology that was highly complementary to water. On a massive scale from the early 1970s onward, governments initiated irrigation projects to upgrade and often to take over existing community-based systems. This intrusion by the State was not necessarily unwelcome in the communities. In most cases, the traditional systems required labor-intensive O&M. By building more permanent structures for free (from the communities' point of view), the government reduced the farmers' burden. But bureaucracies all over the world have tended to be insensitive to local customs and institutions. Consequently, many stories of wasted investment can be recounted.

In many cases where projects were to overlay existing systems, the State or foreign donors' engineers would redesign the infrastructure, substantially ignoring the old system and canal networks. This top-down approach rested on the assumption that the design of the physical infrastructure was the most important determinant of a system's efficiency, to which the management and the social arrangements would naturally adapt (Siy 1987). Where the older system had already fixed the social arrangements, the intrusion of the new system led to conflict, and in many cases, to the disuse, modification, or even intentional destruction of the new structures. The inefficiency of insensitive State intrusion has been demonstrated in case after case, as compared to irrigation systems in which a participatory approach was adopted from the beginning (see, for example, the Philippine studies by Siy [1987] and De los Reyes and Jopillo [1987]).

Even in cases where irrigation was introduced into areas that previously had none, the performance of the systems has tended to be superior when the irrigation agencies has effectively solicited participation from farmers. This is because the social relations that underpin a cooperative venture like community-run irrigation were there prior to the coming of the “hardware” and should therefore shape the design of the hardware to a considerable extent.

Only a few East Asian countries present exceptions to the rule that the central Government has been the driving force in the development of “modern” irrigation systems. Japan’s history of relatively large-scale, farmer-managed irrigation extends back to the 17th century (Nagata 1994). During their period as Japan’s colonies, the Republic of Korea and Taipei,China in turn acquired an organizational framework in which irrigation associations were established to develop irrigation by collecting fees to finance investment and O&M. In the beginning, it was expected that these associations would cover the entire cost—both investment and O&M—but over the years the subsidy element progressively increased and with it the central Government’s role in designing the systems. Nonetheless, the associations still share significantly in the cost (recently about 30 per cent of the total) through long-term, low-interest loans: it is likely that the associations scrutinize the designs more closely if they have to foot part of the bill rather than the Government financing the entire investment, as is standard practice in South and Southeast Asia (Small and Carruthers 1991).

Once the hardware is in place, the O&M of the irrigation scheme has to be considered. There are a large number of ethnographic studies that examine the operation of traditional community-based irrigation systems. Coward (1980) usefully compared a sample of community-based and bureaucratically run systems. Three themes can be discerned. First, community-based systems have rules of accountability: irrigation leaders serve small groups of water users; are selected by members; are subject to review and replacement; and receive some compensation from the members, mostly in kind. Second, even when the irrigation areas are small, they are often multitiered, with even smaller subunits in charge of mobilizing labor and organizing work groups. Third, irrigation command areas are seldom coterminous with village boundaries, complicating interaction between the community and the State, e.g., in the administration of O&M financing and agricultural support services (Coward 1980).

When these systems are examined in equilibrium, they appear attractive. But they are subject to various stresses. Besides State intrusion, two others may be identified. First, since O&M is labor-intensive, if real wages throughout the economy edge upward with development, difficulties may develop in procuring enough labor to maintain the systems (Coward and Levine 1987). Second, as population pressure builds, the system may be stressed internally by increasing water demand and externally by declining water availability because of developments upstream.

Ostrom and her colleagues have developed an analytical approach based on extensive empirical study of a large number of systems (Ostrom 1992, 1993, and 1994; and Ostrom, Gardner, and Walker 1996). These analyses indicate that the open access that characterizes water distribution within most developing Asian countries requires a form of social capital that can be (and indeed has been) developed by communities. The working of this social capital has its own logic, which explains the success and failure of different systems and also the success and failure of government interventions (see the discussion of social capital in Chapter II). In particular, an open-access system need not lead inevitably to overexploitation, as is commonly believed by economists. At the same time, a communally-managed system may not always survive, particularly in the face of misguided intervention by the State.

Ostrom (1996a) spells out the detailed considerations needed to predict whether a rule for allocating water will "work," i.e., whether it will be followed by the individual farmers. An example that she provides is one where the physical layout allows the benefits to be symmetrically distributed, versus the situation that favors one subgroup over another. The most obvious case of the latter is the perennial conflict between farmers near the source of the water (the head-enders) and those far removed (the tail-enders). She demonstrates that in situations where the costs of O&M are large relative to the benefits of the water, the tail-enders may end up with better bargaining power for a more equitable water share, as the head-enders will have to depend on their contribution towards the costs of maintenance. In fact, the higher the costs of O&M, the more bargaining advantage the tail-enders have. Thus, when the government or donor agency makes, say, a bamboo weir more permanent or lines the canals with cement, it may so unbalance the relationships within what had been a working traditional arrangement that the irrigation system ends by being less productive and less equitable than before.

Ostrom (1993) identified the following attributes of the governance structure of a communal irrigation system that has survived for a long time:

- It limits access to a clearly defined group and excludes others;
- It has clearly defined rules that set out who gets how much water, and when;
- Users' behavior is well monitored;
- Violation of rules is penalized;
- Each user is well informed about water availability and other users' withdrawals;
- There is a conflict-resolution mechanism; and
- The rules are situation-dependent and can vary according to external supply conditions.

Thus, one of the key lessons learned during the past 20 years is that a small-scale irrigation system is delicately poised. The capital invested in it is both physical and social.

Improvements to the physical capital may end up being harmful if they undermine the preexisting social capital, which is no less important than the hardware itself.

Devolution of Management in Small-Scale Schemes

Small-scale irrigation provides one of rural Asia's clearest examples of the opportunities for effective "coproduction" by public agencies and participating communities (see Chapter II and Ostrom [1996b]). Having learned the benefits of participation, donors and, increasingly, governments have looked during the past decade to opportunities for transferring some or all responsibility for irrigation management back to the farm communities. Equally, this trend reflects the recognition that fiscal constraints prevent continued subsidization of irrigation in an era of emerging resource scarcity and shifting sectoral priorities. The objectives of transfer or turnover programs generally include some combination of (i) reduced public cost; (ii) improved O&M; and (iii) improved efficiency, accountability, and equity in water use, leading to higher productivity. The extent of turnover has varied depending upon the nature of the scheme, the community, and other sociopolitical circumstances. It has ranged from the reallocation of some or all O&M responsibilities to, occasionally, the complete transfer of ownership back to the local communities. Because of their relatively small size and generally higher level of traditional community involvement, irrigation turnover has naturally gone furthest in the upper- and small-basin environment.

The experience with turnover in a sample of 29 schemes (18 in ADB member countries) was reviewed by the International Irrigation Management Institute[3] (IIMI 1987, cited in Vermillion 1997), focusing primarily on financial performance, the quality of O&M, and the impact on agricultural productivity. The evidence on achievement of

[3] IIMI's name has recently been changed to IWMI (International Water Management Institute).

these objectives of turnover, although positive overall, is somewhat mixed. Where State subsidies had been significant prior to transfer, they have generally been reduced, including public costs for irrigation personnel. Where the studies provided information on service fees, substantial increases in payment rates were reported. However, there is as yet no conclusive evidence about the long-run financial sustainability of the water-user associations (WUAs), in particular their capacity to raise capital for major repairs and periodic rehabilitation. Similarly, there is little evidence that O&M quality has improved or that turnover has led to higher agricultural productivity.

Overall, the IIMI review was complicated by the wide variety of methodological approaches taken in the different country studies. It underlined the need for more systematic collection of primary data using standardized indicators and longer time series. Because of the wide variety of methodologies, it has not yet been possible to assess the reasons for success or failure or, more importantly, the requisite community and public-sector inputs needed for success.

Thus, until a body of more systematic analyses is available, the prospects for turnover must be viewed with cautious optimism. It is unlikely that turnover programs will prove to be a panacea for the problems of cost recovery and sustainability in Asia’s smaller irrigation schemes. Indeed, if the preexisting social capital was damaged during the course of upgrading the systems, it is dangerous to assume that this capital can readily be recreated when the systems are privatized. Turnover programs must therefore be carefully planned and implemented based upon a clear, realistic vision of the objectives, resources, and time frames involved. A cautious, step-by-step approach is required, as is well documented in FAO’s recently released guidelines on irrigation management transfer (FAO, 1998). A fundamental, yet difficult, requirement is that the public agencies involved in turnover need to adopt a new orientation and skills mix, focusing much less on engineering and construction and much more on community mobilization and support.

Large Floodplains

Surface Irrigation

While relatively small-scale communal irrigation has been practiced in upper valleys and small river systems for centuries, the scale of water management in the lower floodplains requires a degree of engineering (both physical and social) that only the central Government can provide. It is not surprising, therefore, that the irrigation systems in the lower floodplains in Asia have been constructed by central governments. Because they built and control the structures, they have also played the dominant role in their management.

Generalization across systems here is even more difficult than in the case of small-scale upstream systems, because in addition to the topographical specificity, it is necessary to contend with political and administrative specificity as well. Nonetheless, one broad conclusion is that the benefits actually derived from the larger systems have often fallen short of what was expected when the feasibility studies were conducted (Chambers 1988; Ostrom 1992).

Of the many reasons why the systems fail to meet expectations (see the discussion on donor evaluations below, characterizing both large- and small-scale irrigation) is that project planners have tended to be (or have been pressured to be) overoptimistic and go for a command area much larger than that for which water is available. The result has been that the amount of water must be strictly rationed. It has proven very difficult to ensure that the rationing at least minimizes the farmers' uncertainty about the amount of water that will be made available to them. Given the vast resources invested, this is tragic, if one considers that the whole point of irrigation is to reduce the uncertainty inherent in rainfed agriculture (Reidinger 1980).

Compounding the design failure is the management failure. Large-scale systems inherently require a governing entity that encompasses the entire water basin, which has often led to an inefficient, hierarchically organized, bureaucratic style of management. One excellent example is provided by Wade (1982), in an unusually detailed study of the operations of water distribution in a large irrigation system of Andhra Pradesh, India. He shows quite clearly that the system did not display the rationality that social scientists since Max Weber have often associated with bureaucracies (see Chapter II). To operate the system efficiently, information flows had to be fast and smooth in both directions. This was clearly not the case in the system investigated by Wade. The structure of incentives and penalties exerted by the organization was such as to ensure a wholesale obfuscation of the information at various levels. Field staff had little incentive to report fully or truthfully to their higher-ups about field conditions. No one, not least the field staff, obtained much reward for reporting the requirements of the farmers whom they were supposed to serve.

With such a structure as the starting point, the challenge is to devise mechanisms whereby an irrigation authority and its personnel are responsive and accountable to the water users, whether agricultural or nonagricultural. It does not matter whether the controlling authority is the central government, as in many medium-sized countries; the state government, as in India; or the water-basin authority, as in the PRC.

Maintaining the Performance of Large-Scale Irrigation Systems

The scale and technical complexity of the large floodplain systems make them unlikely candidates for turnover during the medium term in most of Asia. Management transfer will probably be limited, at most, to subsections of the infrastructure that define logical local management units (e.g., secondary canals). The O&M of major weirs and dams is normally beyond the capacity of WUAs in their present state of development and has therefore been retained by the public sector. At the same time, it is both fair and fiscally expedient to hope that farmerbeneficiaries and other water users will contribute at least some of the costs of the infrastructure. User fees for irrigation and drainage have been introduced in a number of countries, with varying but often disappointing rates of success.

The challenge is to establish effective and transparent mechanisms that firmly link user fees to the cost and quality of the services provided. An essential prerequisite is that the revenues from the fees must be kept as close as possible to their local source in order to ensure that the money is actually used for O&M. In many public administrations, unfortunately, the user fees disappear into the bureaucracy. The amounts the farmers pay in and the O&M provided seldom bear a visible relationship to each other. In Thailand, for example, the water fees collected by the Royal Irrigation Department are transferred to the central treasury, with the result that farmers have little incentive to pay and the department has little incentive to collect. In Indonesia, the irrigation service fee has, after ten years, largely collapsed in a downward spiral of poor O&M, farmer skepticism leading to low payment rates, and still poorer O&M that reinforces the disincentive to pay.

Groundwater Irrigation

The growth of groundwater irrigation has been the second most dramatic episode in Asian agriculture of the last two decades, after the spread of green-revolution technology. Although sparked in many cases by government intervention, the development of groundwater has been a harbinger of the growth of private investment relative to the public capital that has hitherto reigned supreme in the agriculture sector. Groundwater development has been most extensive in Bangladesh, Pakistan, India, and Indonesia. In some cases, it involved conjunctive use of ground and surface water, but, more typically, groundwater is used as a substitute for surface water. In general, it can be concluded that groundwater development has been most successful where it has been driven primarily by the local initiatives of farmers, as can be best documented by the cases of Bangladesh and Indonesia.

Groundwater technology was introduced in Bangladesh in the 1960s by a government agency, later called the Bangladesh Agricultural Development Corporation (BADC). BADC ran a heavily subsidized deep-tubewell program, installing and renting wells to cooperatives, which contributed nominally to the costs of O&M. BADC also rented low-lift pumps and shallow tubewells to farmers, who paid a larger share of the O&M costs themselves. In the late 1970s, the government began to ease BADC out of its role as sole provider of equipment to farmers. Subsidies on shallow tubewells were reduced; instead, credit for purchase and installation was provided. Import duties were reduced and the private sector was, for the first time, allowed to import the equipment. Consequently, the number of shallow tubewells shot up from 22,000 in 1980 to 120,000 in 1984.

A drought in 1983 led to an unusually large depletion of groundwater, particularly in the northern districts (Gill 1983, cited in Mandal, Sattar, and Parker 1995). The concerned government agencies reacted strongly, in part to counter the diminution of their authority that was inherent in private groundwater development. It banned new shallow tubewells in the northern districts and within the command areas of publicly operated surface-irrigation schemes, restricted the imports of small diesel engines and other shallow tubewell equipment, and strengthened the enforcement of tubewell spacing regulations. Most of these measures proved unnecessary because the groundwater level returned to normal in 1984, before any of the measures took effect. Nevertheless, the Government did not begin to reverse its policies until 1987. During 1984–1987, the growth of private tubewells was effectively strangled, but it accelerated rapidly thereafter, with shallow tubewell installations growing to 350,000 by 1993. At present, private operators own all the shallow tubewells and most of the deep tubewells, although the popularity of the latter has declined because of their technical complexity and lack of profitability in comparison to shallow tubewells. Informal markets for irrigation water have emerged, with pumped water being sold either for cash or in exchange for a share of the crop.

The growth in tubewells made a major contribution to the rapid expansion of the *boro* (dry season) rice crop. As will be further discussed in Chapter VI, market-oriented reforms in the distribution of fertilizer and other inputs and gradual liberalization of output markets also contributed to dynamism in Bangladesh's foodgrain sector (Ahmed 1995; ADB 1996a). With greater control of water during dry-season cultivation, the boro crop has made extensive use of high-yielding varieties and fertilizer. Boro yields are about double what is achieved during the wet season, and production increased from 2.6 million tons in 1981 to 6.5 million tons in 1995. As a result, there was optimism that foodgrain self-sufficiency was within reach in Bangladesh. Unfortunately, progress toward this goal has been erratic since then because of the combined results of periodic flooding, political unrest, ill-advised government interventions in the fertilizer market, and farmer response to adverse changes in their terms of trade. Bangladesh nonetheless presents one of Asia's clearest examples of what can be achieved if prices are "right" and markets are allowed to work.

In Indonesia, shallow groundwater that can be extracted by simple tubewell technology is much scarcer than in Bangladesh: the estimated potential area of groundwater development constitutes less than 4 percent of Indonesia's present surface-irrigation area. Most of the area under pump irrigation has been developed privately, usually using shallow groundwater. In contrast, public and donor-assisted efforts to exploit groundwater in Indonesia have focused on deep-tubewell technology, often in the country's drier regions where surface irrigation is difficult to develop.

From the early 1970s to the late 1990s, most of the documented groundwater development was under the responsibility of the central Directorate General of Water Resources Development. The approach involved central responsibility for the groundwater resource investigations, tubewell siting, installation, and initial O&M, including repair and most fuel costs. Considerable effort also went into establishing and nurturing WUAs, with the goals of eventually turning the O&M over to them under the devolved guidance of the provincial irrigation service and using the WUAs as focal points for agricultural extension. As this transfer occurred, the large central subsidies, initially almost 100 percent of the cost, were to be withdrawn.

In a detailed evaluation of this program, Johnson and Reiss (1993) concluded that with the withdrawal of subsidies, the deep wells are unlikely to remain financially viable unless farmers switch from food crops to higher-value commercial crops such as vegetables and tobacco. Where this substitution has occurred spontaneously, the deep wells have been only marginally attractive investments, even though the WUAs have often proved cohesive and backstopping has been provided by central and local irrigation agencies after management transfer. More often, however, the sophistication of the technology, combined with the scarcity of agricultural extension and credit services, has led to the prognosis that the tubewells would be sustainable only with the continuation of public technical and financial support.

The Bangladesh and Indonesia cases clearly show that farmers, when left to themselves and where the water table permits, have a strong preference for relatively cheap, simple, and flexible technologies. Even in drought-prone areas, deep tubewells have usually proven to be too technically sophisticated and financially unsustainable in the absence of significant subsidies. A basically similar conclusion emerges in India; see the studies on deep tubewells in Gujarat and Uttar Pradesh in FAO (1995). Deep tubewells require a much higher level of maintenance expertise, often exceeding local skills. Effective cooperation among a much larger group of farmers is needed than for shallow tubewell technology. Moreover, the deep tubewells are permanent structures, whereas shallow tubewell engines can be readily moved from place to place, thus allowing more efficient use of capacity. The lesson is that the State should promote, or at least not restrict, a range of environmentally sound technology choices by farmers.

Unregulated groundwater extraction can rapidly lower the water table and, in coastal areas, contribute to salt water intrusion. Both agricultural and nonagricultural users will suffer, particularly rural households that often draw a large share of their water needs from the ground. The more intensive use of agrochemicals associated with groundwater development and natural geologic characteristics can also adversely influence water quality. For example, natural arsenic content exceeds the concentration permissible for drinking water in a significant share of the tubewells in Bangladesh. For these reasons, private groundwater development must be complemented by a suitable State role in water table and water quality monitoring, backed up, as required, by regulatory mechanisms. Possible approaches to the latter include well and pump licensing, pricing, and legal and institutional interventions (Rosegrant 1997). Such approaches, however, are difficult to apply in the case of shallow tubewells, which are private, widely scattered, mobile, and therefore inherently difficult to monitor.

BASIN-WIDE CONSIDERATIONS

It is well known that water is becoming increasingly scarce in Asia. Water scarcity is hardly new, but it has traditionally been primarily a seasonal phenomenon. ADB's developing member countries are mostly in the monsoon zone, with a long dry season during which there is little rainfall. Water shortages during the dry season can be severe, while at the same time the risk of flooding during the wet season is significant. The desire to balance water supply across the wet and dry seasons has prompted massive investments in water storage and flood control. Increasingly, though, and apart from the seasonal dimension, spatial and sectoral dimensions of scarcity have come to the fore. As irrigation takes up much the largest share of the water in most Asian countries, and as agriculture's share in national income declines, it is not surprising that the agriculture sector is under increasing pressure to release water to meet expanding industrial and household demand.

The international community has increasingly drawn the attention of policymakers to the need for the holistic and participatory integration of multisectoral water policy, development, and management. The World Bank, ADB, and other donors have recently adopted, or are in the process of preparing, comprehensive water-resources policies. To its credit, ADB (1996b) has made the recent development of its own water-resources policy as participatory as possible, involving officials of all member countries in a truly consultative process. There will nevertheless be substantial obstacles to the hands-on application of holistic principles in developing-country environments. Carter (1998) includes the following:

- The perception that water rights are "God-given," i.e., water is not seen as an economic good;
- The short planning horizons and political uncertainty;
- The widely accepted authoritarianism and paternalism of Government; and
- The lack of community empowerment, both among rural communities generally and among specific stakeholders, such as women.

To the above should be added the natural resistance of bureaucracies to relinquishing power, either through decentralization or through the reallocation of power to higher policy-making bodies. To overcome these cultural and institutional obstacles, the international community—and the donors in particular—will need to be both patient and persistent in using their leverage to encourage the effective adoption of broad agendas and policies for water resources.

Asia's success in finding ways to manage water scarcity will be a key determinant of agricultural and rural growth in the future. Chapter IV showed that part of the solution should come at the farm level through research and technology development for resource-constrained agriculture. The main concern of the present chapter is the management of water before it reaches the farm. The annual supply of fresh water is largely fixed. Groundwater is part of that supply and can be mined temporarily, but ultimately its use cannot exceed the recharge. Desalinization of seawater is not considered an economically viable option. That said, within a given water basin, there are three interrelated ways by which water scarcity can be addressed: (i) more infrastructure can be developed to store and control the water supply across and within seasons, (ii) the fixed seasonal supply can be managed through administered rationing, or (iii) demand can be managed through pricing mechanisms.

Supply Augmentation

The traditional approach in Asia, much accelerated by the food and energy crises of 1972–74, has been to build new water-storage capacity, together with downstream works to expand the irrigated area. Since the mid-1980s, however, the rate of investment has slackened considerably for a variety of reasons. With regard to irrigation, decisions to invest are made by national governments, often in collaboration with donors, both presumably seeking to maximize social welfare. By methodological convention, the social profitability of irrigation is determined largely by the world prices of the crops produced. Kikuchi and Hayami (1978) showed that irrigation investments have varied in tandem with world rice prices. The huge investments of the 1970s and 1980s doubtless contributed to the secular decline in real world cereal prices that has, with the principal exception of the early 1970s, continued unabated since the 1950s (see Figure VI.1 in the following chapter). With a declining rice price as the numerator in the profitability equation, the denominator—irrigation construction costs—has increased rapidly over time as less and less favorable sites have been developed. Rosegrant (1997) presents figures showing that, on a per-hectare basis, the real capital costs of new irrigation increased by more than 150 percent from 1966 to 1988 in the major countries of South and Southeast Asia.

Social and environmental considerations have also increasingly influenced investment decisions. Most prominently, large storage dams usually face strenuous objections from environmentalists, who have made common cause with involuntarily resettled people (see Vajpeyi and Zhang [1998] for a good summary of the issues involved). In many countries, displaced people have good reason to be opposed (sometimes violently) to the prospect of having to leave their homes, particularly when practices in the matter of compensation have been unsatisfactory.

Thus, with declining returns to investment, rapidly growing nonagricultural competition for water, and much greater weight given to social and environmental factors, the justification for major investment in water storage and irrigation grows steadily weaker. With few cheap water resources left to be exploited, the basic water resources infrastructure, both for irrigation and nonagricultural uses, is largely complete in the "closing" river basins of densely settled Asia.[4] Megaprojects such as the PRC's Three Gorges Dam and Indonesia's Kedung Ombo Dam will certainly be exceptions rather than the rule in the future. The main issues now center, first, on improving and sustaining the performance of existing infrastructure and, second, on the more efficient allocation and use of the available water supply.

Administered Rationing of Supply Among Water Users

The "command and control" system of bureaucratically determined water allocation for irrigation is still overwhelmingly followed to this day, with various ad hoc allocative arrangements made for nonagricultural uses. The flow of water is controlled by officials who may or may not be responsive to the needs of farmers. By rotating the water or by other means, they will distribute whatever water is available among the users, a process that may or may not be perceived as fair by anyone.

Water authorities are generally able to regulate the supply only in irrigated areas. In most countries, there is no regulation

[4] Keller, Keller, and Seckler (1996) define a "closed" water system as one in which no usable water leaves the system, e.g., by flowing to the sea. Interdependence among users only becomes a meaningful issue as water systems close and water demand comes to exceed supply.

of extraction outside the irrigation command area. Indeed, some countries protect the rights of citizens (including industrial users) to the water, which thereby becomes an open access resource. Consequently, agricultural uses become a residual, not only by a conscious decision of policymakers, but also because of the poverty of regulatory instruments.

A common complaint has been that, in cases where a storage dam also generates electricity, irrigation is slighted in favor of electricity (Reidinger 1980). Since water that turns a turbine could then, in principle, be used to irrigate crops, such criticism inevitably involves the dimension of seasonality. If the authority controlling a dam were to ignore irrigation and solely maximize the production of electricity, then it would be better to fill the dam up to the highest level and keep it filled. If this were done, the production of electricity per cubic meter of water released would be maximized. But keeping the dam always full would mean that the outflow of water at any moment would, together with evaporation during storage, be equal to the inflow. Such a strategy would mean that, from the point of view of the farmers downstream, it makes no difference whether there is a dam. Hence, to the extent that the release of water is manipulated to provide for irrigation, the level of water behind the dam will fluctuate to levels below its maximum. In fact, in areas where there is a pronounced dry season, the level of water behind the dam is commonly reduced to its minimum just before the onset of the rains. Electricity generation is sacrificed, because at such a low level the amount of power generated per cubic meter of water released is considerably reduced.

There is greater flexibility to release water for irrigation, however, if hydroelectricity from the dam is but a small proportion of the total electricity demand of the country concerned. If this proportion is large, then irrigation requirements tend to give way to the imperatives of electricity generation. Lest this seem unfair, it should be noted that rural development is also fostered by a steady supply of electricity. Hence, any conclusion about the relative merits of the agriculture-hydropower trade-off should be based on an understanding of the relative productivity of water in the two uses in differing seasons of the year.

Demand Management Through Pricing Mechanisms

Demand management focuses on creating the incentives for water to be allocated efficiently among and by competing users and sectors. As mentioned already, water in most Asian countries has traditionally been viewed as a natural "gift of God." Since it is either free or priced well below its opportunity cost, it is not surprising that demand often exceeds the available supply, particularly during the dry season. Where water is costless, it is equally unsurprising that farmers tend to waste a lot of it. Any move to alter demand through pricing mechanisms cannot but have a profound impact on the relative roles of the State irrigation authority (however organized), the private sector, and the individual communities.

Outside of the wholesale privatization of irrigation, which is not considered a realistic option for Asia's large-scale systems during the medium term, there are two generic and interrelated market-based approaches for forcing demand to match supply. The first is to levy a charge for water use. Discussion about user fees usually focuses on the recovery of investment and O&M costs, but consideration may also extend to broader economic, environmental, and social opportunity costs. From both a theoretical and practical standpoint, calculating these costs for what is usually a nontraded good presents significant challenges (Young, 1996).

One technical problem is that for the user fee to be fair, the rate should be based on the volume of water consumed. Water "consumption" is distinct from water "diversion." When water enters farmers' fields, they are said to have "consumed" it, but a great deal of that water will then either flow into neighboring farmers' fields or drain into the soil and become part of the groundwater. The only part of the water that is "consumed" and thereby no longer available to other users is that which either evaporates or is used by the crop for evapotranspiration.[5]

[5] In cultivating paddy, farmers have a great deal of standing water in the field, but do not consume it. Rice paddies are kept continuously flooded during the initial growth period not simply because water is a free good, but also because flooding retards weed growth and is necessary for the field-to-field water flows required by the irrigation systems. In contrast, water diversions are much closer to actual consumption under sprinkler or drip irrigation.

Obtaining this measure is almost impossible, but it would be necessary for a fair, efficient allocation to be achieved.

But if some error is tolerable, charging a fee by the volume diverted can serve in lieu of a precise fee for the volume consumed. The more difficult questions with a user fee are legal and administrative. For the government or any authority to charge a user fee, it must first establish a claim to what were traditionally viewed as God-given water rights. This will entail largely doing away with the open-access regime. Furthermore, for the fee to achieve its purpose, it must be levied both inside and outside the irrigated areas. From a practical standpoint, the collection of fees—indeed, even just identifying all the users—is arduous, but there is scope for charging the fees at the level of the community or WUA. All in all, the administrative and political costs of using water fees as an allocative device will be high in most countries.[6] But the results of continuing inaction will be equally unacceptable.

The second possibility is to create a market for tradable rights to water. For this to happen, clear rights to the water must be established. For surface water systems, there are two basic principles as to what kinds of rights can exist.[7] In an advanced (and dry) economy such as the United States, there are complex legal doctrines pertaining to water rights (see Carlson, Zilberman, and Miranowski [1993] for a listing and brief description). In

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[6] Political objectives—the desire for rural prosperity and stability—have doubtless tended to perpetuate subsidies for irrigation and water throughout Asia. Chapter VI examines these objectives in the context of Thailand, Malaysia, and Indonesia.

[7] The first, called the riparian doctrine, allows users to take water from a river system only for use on land adjacent to the river and only insofar as the water returned to the river is similar in quantity and quality, and so does not reduce downstream use. The second, called the appropriation doctrine, allows a specified quantity of water to be diverted, stored, and used on lands that may or may not be adjacent to the river. The riparian system has been used largely in regions where water supply exceeds demand, while the appropriation system has been adopted more frequently in water-deficit regions. Variants on the appropriation doctrine make specific provision for allocating water during periods of scarcity, i.e., with rights adjusted on either the basis of the seniority of the water claim ("prior appropriation") or in proportion to the available supply ("proportional appropriation") (Simpson and Ringskog 1997).

Asia, detailed legal frameworks for water rights are often nonexistent, but the impetus for legislative change can only grow with the increasing scarcity of water.

Faith in market mechanisms for resource allocation has been "politically correct"—often approaching dogma—for more than a decade. Although attractive in principle, the complexity of establishing markets for tradable water rights should not be underestimated. Simpson and Ringskog (1997) set out the prerequisites for this to occur:

- The demand for water must exceed supply;
- Water rights must be clearly defined in terms of ownership, quantity, measurability, and reliability;
- There must be adequate infrastructure so that supplies derived from use rights can be transferred between locations when needed;
- Property rights to water must have an enforceable legal basis, which requires a system of allocation, property titling, and regulation that is respected by the market;
- The water rights system must be able to resolve conflicts in a manner that is perceived as impartial, predictable, and timely, including situations where water rights are overtaken by eminent domain;
- The system must apportion supply equitably during periods of shortage and excess;
- The system must reflect the cultural and social values of water use; and
- The system must be financially sustainable.

The above list appears daunting. At the very least, it should indicate that the setting up of tradable water rights at the level of the individual farm or water user will be physically and administratively impossible in most of Asia. It may be feasible, however, to split up the jurisdictions of the water authorities into subbasin entities whose officers are accountable to the people living in them. These entities would then be endowed with water rights in conformity with their traditional demands on the water resources and it would be these entities that would engage in trade. Depending upon sociopolitical circumstances, the entities could be public (e.g., elected officials), community-based (associations of WUAs), or even private (water companies working under contract), as long as their accountability is assured.

Whether supply and demand are managed through rationing or price mechanisms, the technical scope for improving water efficiency is considerable in Asian agriculture; the incentives for doing so will be enhanced if there are effective pricing mechanisms. The field efficiency of water use—i.e., the amount consumed in evapotranspiration as a proportion of the amount diverted—probably averages just 50 percent in most of Asia, and is often as low as 25 percent. The establishment of an effective pricing mechanism would be a powerful force to encourage conservation. At least for high-valued crops (but probably never for rice, given its high water requirements), sophisticated techniques such as sprinkler, drip, and surge irrigation will become economically rational if the scarcity value of water is sufficiently high. The diffusion of these techniques would be a very appropriate role for the private sector. In addition, opportunities for conservation also exist at the irrigation-system level through real-time management based upon improved monitoring and information flows about weather, water levels, and field conditions (Rosegrant 1997).

Upper Watershed Management and Common Property Rights

In one way or another, water is at the heart of the major environmental problems associated with Asian agriculture. Deforestation and the cultivation of annual crops on sloping land may reduce natural water-holding capacity and, by accelerating erosion and sedimentation, increase the seasonal variability of downstream water flows.[8] A central problem is that forested upland areas, even if technically governed by the State, are usually *de facto* common property. They are subject to the dispersed decision making of resource-scarce families, who may respond to incentives that provide them with opportunities to improve their welfare but who will not be swayed by unenforceable resource management laws and administrative instructions.

Technical solutions are available to reduce the external costs of forest encroachment and soil erosion (e.g., bench terracing, alley cropping, and agroforestry), but socially acceptable solutions have proven far more elusive. The principles of property rights to land (Chapter II) and greater community empowerment for the management of common resources are now seen as prerequisites for watershed conservation. Finding workable means of implementing these principles has been, and will continue to be, a challenge for governments and donor agencies.

Donor Roles: Doing More by Doing Less?

The above discussion alluded to donor roles in Asian irrigation development. Indeed, donor financing of irrigation development has been far more extensive and instrumental than for the other rural goods and services considered in this volume. Irrigation and irrigation-related projects have accounted, cumulatively, for about 10 percent of the *total* lending of ADB and the World Bank (the total would be considerably larger if projects for flood control, hydropower generation, and urban and rural water supply were included).

[8] Calder (1998) examines the conventional wisdom regarding the relationships between forest cover, soil erosion, water runoff, and dry-season flows. He concludes that the many intervening variables, most importantly the use of land after it has been deforested, preclude the widely held generalization that deforestation inevitably reduces water holding capacity.

Irrigation lending peaked in the late 1970s for the World Bank and in the early 1980s for ADB; it remains an important part of their portfolios. Irrigation has also been prominent in many bilateral assistance programs, most notably those of Japan and, historically, the US. In many countries of Asia, it is fair to state that donor financing has been the engine of growth in public-sector irrigation development and policy since the 1970s. It is, therefore, relevant to ask what the donor experiences have been, what lessons have been learned, and what implications can be drawn for the coming 10–15 years.

Both ADB and the World Bank have conducted detailed post-evaluation studies of the performance of their irrigation projects (see the summaries in ADB [1995b] and World Bank [1994]. Both banks acknowledge that a significant number of their projects have not performed as expected. In the case of ADB, *ex post* economic rates of return on all irrigation projects averaged 10 percent, as compared to appraisal estimates averaging 19 percent. Although the evaluation methods differ, the World Bank may have fared somewhat better, averaging an *ex post* 15 percent as compared to 22 percent at appraisal. Nonetheless, common lessons have been learned and applied.

Environmental and social concerns, along with beneficiary participation, are now explicitly incorporated at the outset of project planning. A more integrated river basin perspective is being taken in irrigation development, focusing on both the water resources and the upper watershed management issues. Designs require more reliable resource assessments of geography, soils, and hydrology. Project formulation and design give greater attention to the institutional, social, and cultural environment and to the sources of poverty and unsustainable resource use, rather than focusing on technical and engineering aspects. Sustainable institutional, technical, and financing mechanisms still need to be established for O&M. Greater modesty is required in estimating project economic rates of return, which have proven particularly sensitive to rice prices and to the assumed levels of cropping intensity, input use, and productivity. Finally, a longer-run perspective on the capacity building of executing agencies and community organizations is needed. The application of these lessons is, hopefully, leading to better-performing and more sustainable irrigation projects.

One lesson remains—the incentives of lending momentum—for which the Asian economic downturn may give useful pause. Asia has built many expensive irrigation schemes, only to discover that they are unsustainable. Even so, there has often been continuing replenishment by donors of funding to rehabilitate and "improve" poorly performing schemes. This has reinforced the innate motivation of public irrigation agencies to build rather than to sustain physical capital and to ignore the equally important "software" sides of irrigation. With government capacity to provide counterpart funding for irrigation projects now severely strained in much of Asia, the time is ripe for the developing countries to look to their own resources in order to refocus the agencies on sustainable O&M of the existing systems and, usually at a higher level of government, on the integration of water-resources planning, development, and management.

SUMMING UP

Because of its past investments in the structures of water control and because the legal and institutional mechanisms for allocating water are still undeveloped, the State remains the dominant force in the rural water resources arena (Table V.1). The principal exception has been the growth of groundwater. If any change is to be detected at the moment, it is in the reorganization of State institutions in charge of water basin management, with a broader role now envisaged than that of mere irrigation management. There is, in general, a movement toward having each water basin under the jurisdiction of its own management authority. The challenge will be to work out a system whereby this authority can be made accountable to the basin's water users.

The huge investments in irrigation should be made to pay by better management of the systems. The general trend over the last two decades has been toward various experiments in devolution and user cost recovery. Ultimately some of these experiments will become models for other countries to follow.

Overarching the performance of irrigation is the emerging water shortage, a consequence of the past growth in cropping intensity as well as growing industrial and household use. In monsoon Asia, the main problem will come during the dry season and periodic droughts. This will require a much more careful look at the management of the water resources within entire water basins in many parts of Asia. The role of the central government in allocating water resources will have to be modified to one where it is the referee in a system of trades, not among individual water users, but among large groups of users organized in the various subunits of the larger basins.

Table V.1 Comparative Advantage of Different Actors in Irrigation

Product	Current Situation	Future Comparative Advantage	Developmental Needs
Small-scale irrigation development and rehabilitation	Coproduction by public irrigation agencies and the communities	Increasing design and financing role by the communities, with support from the State	Reorientation of the engineering and project focus of public irrigation agencies
Large-scale irrigation development and rehabilitation	Public agencies	State role will continue. In large *and* small systems, the private sector will dominate the diffusion of water-conserving, farm-level technology if price incentives warrant.	Full application of the "lessons learned," together with demand management policies
Groundwater development	Private sector, with technology advice provided by public agencies	Same, but growing role for private sector in technology diffusion	Legal and institutional frameworks for environmental regulation must be strengthened.
O&M of small systems	Coproduction (farmers in charge of small canals, public agencies responsible for dams, weirs, and headworks)	Communities, with advice by public agencies	Reorientation of public irrigation agencies. WUAs need to be "empowered."
O&M of large systems	Coproduction	Same, with greater financing share by farmers and some management transfer of secondary canals	Transparency and local accountability in the use of water fees, Empowered WUAs
Environmental monitoring	Public agencies	Will remain publicly financed, possibly with monitoring services provided by the private sector or community-based organizations	Laws and institutions for environmental regulation must be strengthened.
Basin-level water allocation	Public agencies, through "command and control"	Public agencies, as mediators of trade across sectors	Laws that define and institutions that enforce water rights, integration of water policies and sectoral water agencies, mobilization of private entities or community-based organizations to engage in trade.