IWMI Research Report

145

Water Productivity in Context:
The Experiences of Taiwan and the Philippines over the Past Half-century

Randolph Barker and Gilbert Levine

International Water Management Institute

Research Program on Water, Land and Ecosystems

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Front cover photograph shows farmers setting up a water pump to irrigate their fields in the Philippines (*photo credit:* Isagani Serrano/IRRI on Flickr).

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The authors have been involved in various aspects of water management in Taiwan and the Philippines since the 1960s. Over that period, we have worked with colleagues on research, trained a number of graduate students and written numerous articles. This report attempts to bring together what has occurred and what we have learned over the past half a century.

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Collaborators

International Water Management Institute (IWMI)

Cornell University

International Rice Research Institute (IRRI)

Council of Agriculture, Taiwan

National Irrigation Administration, the Philippines

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Summary

This paper first describes the potential ways in which increased water productivity can be achieved in the context of rice production in Asia. It then illustrates the ways in which the differences in the environmental context affect the ability to increase water productivity, the approaches used and the incentives to do so. This is explained using two 'case studies' reflecting the experiences of Taiwan and the Philippines over the past half-century. Seven conclusions are drawn from the study, but the general conclusion is that irrigation systems evolve more in response to changes in their political, social and economic environments than to changes in their physical environment. To be successful, attempts to improve a system's performance must recognize, and either change or accommodate to adverse aspects of those environments.

Water Productivity in Context: The Experience of Taiwan and the Philippines over the Past Half-century

Randolph Barker and Gilbert Levine

Introduction

It is widely recognized that the requirements for managing water resources effectively vary geographically and over time. In many situations there is pressure to save water, to increase water productivity or to do both. These time-related changes reflect increases in demand from users other than agriculture, such as municipality/ industry users and the environment. There are also variable impacts from government policies often influenced by international aid and regulatory agencies. The challenges for farmers, irrigation managers and water-resource policymakers are to identify and implement water policies and practices that are appropriate for the place and time, and to ensure that the institutional climate is such that these can change as the need changes.

The response to the need for change reflects the technical options available to farmers and irrigation managers, costs of those changes, institutional character of the management of irrigation, and the economic and political environments at the time. In the following sections we will use the examples from Taiwan and the Philippines to illustrate the influence of these factors on the extent and nature of the governance of water resources for irrigation. The two cases reflect relatively large differences in the general context within which irrigation has evolved, thus providing the opportunity to enhance understanding of the influence of the sociopolitical environment on the need for improved water management. This is facilitated by the fact that over a number of years there has been substantial research on irrigation water management in both countries.

There has been sustained research interest in Taiwan's irrigation sector because of its contribution to agriculture and the rapid development of the industrial sector. Similarly, there has been a significant number of studies on irrigation in the Philippines, but this has primarily focused on farmer participation or *irrigation management transfer* (IMT) both in *communal systems* (CIS) and in the *national irrigation systems* (NIS). This paper will focus on placing the changes in the management of irrigation water that have taken place over the past half-century in the broader economic, social and political contexts within which the sector changes have occurred. To a considerable extent, the two cases also reflect the differences in the development and management of water resources for irrigation found in East and in South/Southeast Asia (see, for example, Shah et al. 2004).

Defining *Water Productivity* in Physical and Economic Terms

Increasing water scarcity is not a consequence of there being less water, but rather there being more demand for existing water resources. In the context of water scarcity the need for water 'saving' is frequently expressed, with an emphasis on *greater irrigation efficiency* and *increased water productivity*. However, each term has a different meaning, causing confusion. Water saving is typically defined as reducing the amount of water used in growing a crop, without reference to the yield of the crop. Increasing efficiency (defined as the amount *utilized* by the plant divided by the amount diverted) is similar, in that it ignores the element of crop yield, but introduces the element of crop utilization of the water. Increased water productivity – the yield (either magnitude or value) per unit of water applied – explicitly changes the focus from the water to one that includes both the crop and the water. Neither of the former, water saving and increasing water efficiency, considers the benefits and costs of the increased control and management that would permit a reduction in water diversion (Kijne et al. 2003).

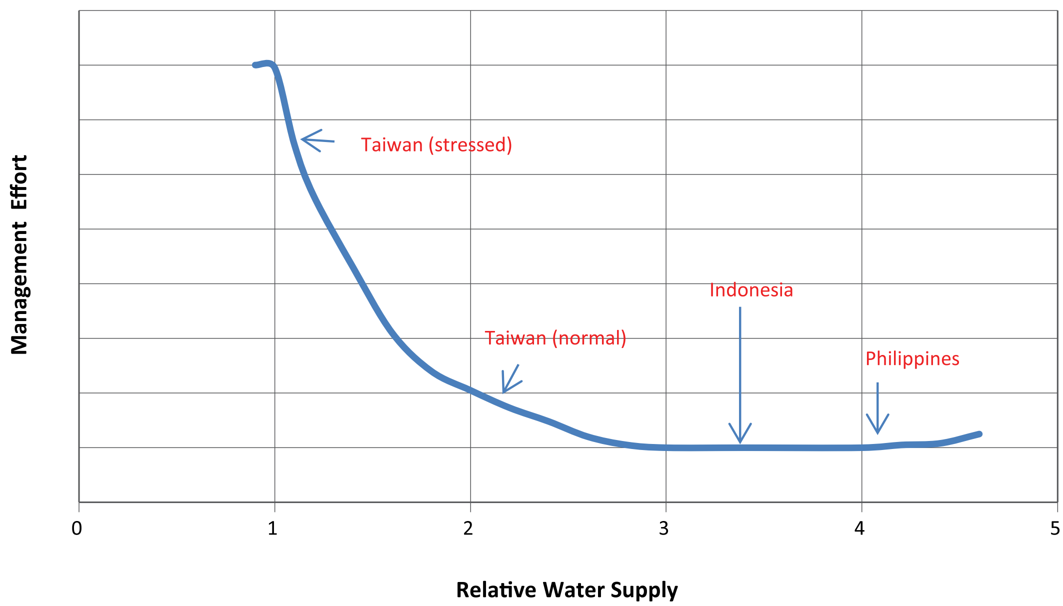
Thus, water saving, in our view, should be viewed from the perspective of increasing the *productivity of water* (WP). The potential for increasing productivity can be evaluated by considering both the physical and socioeconomic components that define it. From the physical perspective, we look at the water itself. From the socioeconomic perspective, we consider both the ways the water is used and the value (both market and social) that is derived from it. It follows that from the socioeconomic perspective it is important to differentiate between water that is used productively (including the environmental benefits) and that which is nonproductive (Molden et al. 2003).

To determine how much water might be diverted to uses other than the specific crop being grown, it is important to differentiate between the water that is 'saved' at the farm or system level from that which is 'saved' at the watershed or basin level (sometimes referred to as *real water savings*). What may be identified as 'waste' or 'excess' at the farm or system level may actually be a 'resource' that is used at a location downstream in the watershed. Thus, it is important to consider the water disposition within the watershed downstream from the area in which water saving is encouraged to determine the full impact of any changes. The potential options for water saving are greater in those basins where not all of the water has been allocated ('open' basins) than for those in which essentially all the water has been allocated ('closed' basins). In the former, utilizing the unallocated water to increase water productivity without necessarily affecting current uses is a likely priority; in the latter case, options for physical water saving and obtaining higher value from the existing or new water uses are limited. All of this suggests the need for *water accounting* to determine the productivity and value of water in its old and new set of uses at the basin level. In short, most 'water savings' are not easily identified and quantified. As a result, even where water is in short supply, there is often little incentive on the part of suppliers and users to save water.

It also should be recognized that *water saving* can occur from different types of efforts, some of which do not require improved management of water resources per se. It is usual to think of the reduction in the amount of water used, but water saving is in fact occurring when efforts are made to increase the output per unit of water used, both of which can be expressed as an increase in water productivity or 'crop per drop'. Over the past few decades, a significant portion of the increase in water productivity has been due to the success of plant breeders in partitioning plant biomass toward economic yield for both rice and wheat, in other words, by changing the 'harvest index' from 80% shoots and 20% grains to 50-50 (Kijne et al. 2003; Keller and Seckler 2008). While the objective has been to increase economic yield per unit of land, it simultaneously provided an increase in the economic yield per unit of water used. The water savings covered a huge geographic, largely irrigated, area where this technology (plant biomass partitioning) was adopted. The potential for further gains from this type of partitioning is limited (Zwart and Bastiaanssen 2004). However, breeding varieties for tolerance to *abiotic stresses* (flooding, drought, salinity) can increase water productivity. A case in point is the newly identified sub1 gene, which when inserted into rice varieties can allow the plants to stay submerged for as long as a month (as opposed to a few days) and recover when the floods recede (Fukao et al. 2008).

Improved agronomic practices have also had positive impacts on yield per unit of water used, as well as on yield per unit of land area. These include such practices as alternate wetting and drying of paddy fields, modification of planting rates and direct seeding of rice, all of which can be effective, but only when water is available as needed (Li and Barker 2004). In some locations, efforts can be made to reduce evaporation due to standing water by coordinating flooding and transplanting more appropriately, improving drainage, shifting the time of planting, etc. The difficulty here is that these practices are not often adopted system-wide or basin-wide, and it is thus difficult to measure its impact in terms of *real water savings*. A third avenue for increasing water productivity relates to better design and management of the irrigation system. People often marvel at the successful management of local or community irrigation systems such as the *subaks* of Bali in Indonesia or the *zangjeras* in the Philippines (Coward Jr. 1980), but bemoan the fact that so many of the large public irrigation systems are poorly managed. Also, from the economic perspective, the cost of water savings must be recognized, both from the standpoint of magnitude and who pays. While the costs of water-saving efforts vary depending upon the specifics of those efforts, in general, the costs are relatively low when the water used for irrigation is relatively abundant, but increase at an increasing rate when the supply is reduced significantly. Figure 1 illustrates the nature of this relationship, with *relative water supply* (RWS)[1] as the independent variable, and *managerial effort/costs* as the dependent variable (Levine 1982). As stated previously, the absolute values will differ depending upon the type of water-saving efforts. The illustration suggests

FIGURE 1. Water managerial effort/costs versus relative water supply.



Source: This study.

[1] Relative Water Supply (RWS) is defined as the ratio: water supply available to the crop/water required by the crop for full yield. The water required includes the necessary evaporation during land preparation, evapotranspiration and drainage required for salinity control. In many Asian systems, the seasonal water requirement varies between 600 millimeters (mm) and 700 mm.

that there is a rapid rise in managerial costs as the supply approaches the basic requirement, a RWS of 1. The rise in effort as the RWS value increases beyond 3 (i.e., too much water) implies the need to address potential drainage problems. The managerial effort required to save water may be primarily at the farm level, or shared at some level higher in the system. However, as the data presented later will show, this can be significant.

Finally, water productivity can be increased on a global scale by meeting some of the local demands for water through 'importation'. For example, Mexico uses much of its limited water supply to irrigate high-value crops which it exports to the United States of America (USA), from whom in return it imports lower-value grain (Barker et al. 2000). Currently, China is also following this practice (National Bureau of Statistics of China 2009). The water associated with the production of the imported crop, referred to as *virtual water (*Allan 1998), represents an implicit addition to the water supply of the importing country.

What follows in our two cases generally focuses on surface water resources, but is relevant to groundwater as well. Where groundwater is accessible at an affordable cost, increasing its use can lead to increased water productivity through the potential for improved control of the timing of irrigation needed, for example, in producing high-value crops. When groundwater is used conjunctively with surface water there can be a significant water saving. In situations of groundwater overdraft, physical water saving becomes important.

Background and Setting for Irrigated Agriculture in Taiwan and the Philippines Prior to 1960

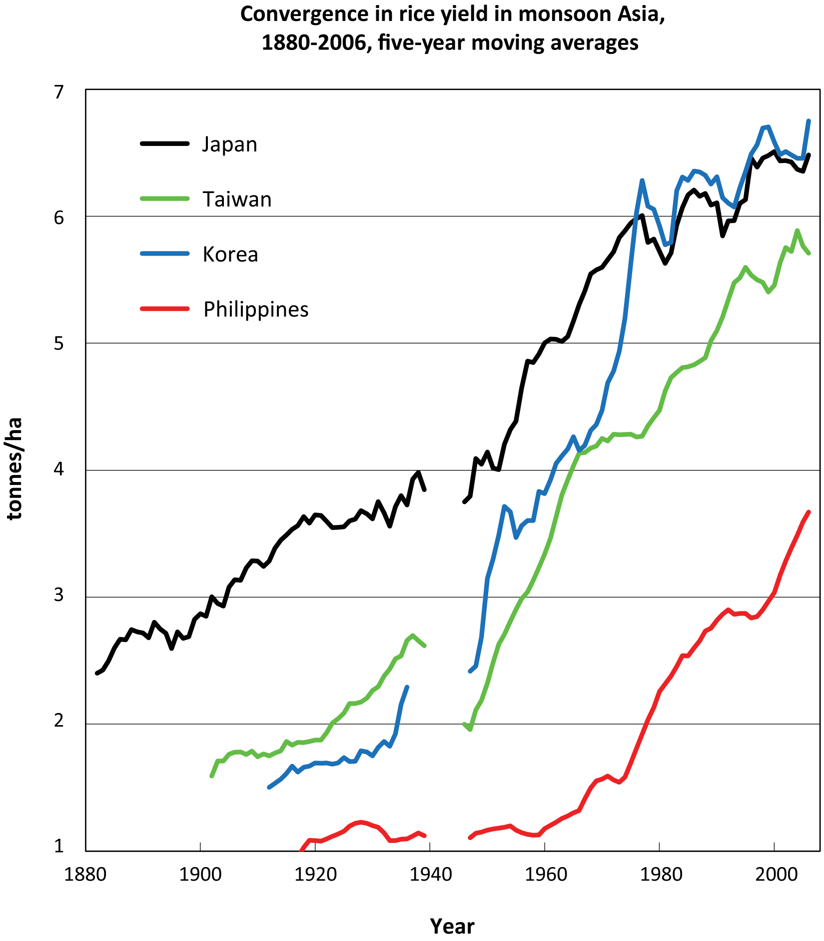
During the first half of the twentieth century, both Taiwan and the Philippines were ruled by colonial powers. From 1895 to 1945, Taiwan was ruled by Japan, and the Philippines was ruled by the USA from 1898 to 1945 (omitting the years of Japanese occupation). Here is where the similarity ends, and the need to identify and contrast agriculture and irrigation of the two countries begins.

Taiwan: 1900-1960

A major objective of Japan was to obtain rice imports from her two colonies, Taiwan and Korea, and hence increasing rice production became a high priority for these two countries. However, the opportunities for expansion of the agricultural land area were limited. The land frontier in Taiwan closed in the 1920s and the typical farm size of 2 hectares (ha) began to shrink (Lee 1971; Rada and Lee 1977). Following the strategy adopted after the Meji Restoration (1868), Japan's colonial government invested in irrigation infrastructure, developed improved *ponlai* (japonica) varieties and encouraged the use of fertilizer. Irrigation and farmers' associations were created but controlled by the colonial government with an iron fist to ensure that farmers' made payment of irrigation fees and taxes. As a result, during the first part of the twentieth century, first Japan and then Taiwan and Korea experienced a yield-increasing 'green revolution' in rice (Figure 2)[2]. This was an event that did not occur in the Philippines and the rest of South and Southeast Asia until the 1960s.

[2] One needs to be cautious about comparing national yields across countries. For example, yields are higher in Korea (and northern China) than they are in Taiwan (and southern China) due to climatic factors and cropping patterns – one crop in the north versus two shorter-duration crops in the south. Comparing Taiwan and the Philippines, as much as 20% higher yields in the former may be due to the fact that yields are estimated by crop cut, while in the Philippines yields are estimated by survey, dividing the values reported for total production by the area. Other factors may also come into play.

FIGURE 2. Rice yields in monsoon Asia (five-year moving averages).



Source: Kikuchi and Hayami 1978.

Thus, development of irrigation combined with the seed-fertilizer technology was seen as the model for land productivity growth adopted decades later in the tropical Asia (Ishikawa 1967).

Rice production collapsed in Taiwan during World War II. The subsequent defeat of Japan in the World War, and influx of people from the mainland in 1948, challenged the Nationalist government to achieve the pre-war annual growth in rice production of over 3%. An initial major undertaking in 1953 was the '*Land to the Tiller'* program, which transferred land from landlords to tenants with approximately 40% of all farm families benefiting from the program (Yager 1988). During the 1950s, only 30% of the total outlays for irrigation were for investment, the remaining amount was mainly for maintenance and repair expenses due to neglect and war *damage* during the 1930s and 1940s and recovery adjustments during the 1950s (Rada and Lee 1977). The number of irrigation associations was reduced from 40 to 26. Of the 870,000 ha of cultivated land, 60% was irrigated mainly for rice (Ko 1997). The average farm size was a little over 1 ha. A number of technical and management improvements for irrigation were initiated, which will be discussed in more detail in the section, *Irrigation and Water Management Practices in Taiwan and the Philippines over the Past Half-century*.

Philippines: 1900-1960

Under American occupation, the agricultural economy of the Philippines was dominated by the production of export crops such as sugar, copra, abaca and tobacco. From 1900 to 1960, the land area devoted to agriculture expanded at an average rate of 3% per year; growth in the latter part of the period being focused on Mindanao. Throughout this entire period there was virtually no increase in the per hectare crop yields for all commodities including rice.

Early on, sugar became the primary export because of the strong demand for it in the USA and also due to the protection given by that country to products from the Philippines. This 'plantation agriculture' gave rise to landed elite families which have dominated politics, even to this day.

The total irrigated area expanded to keep pace with domestic demand for rice. However, in the 1930s, planned expansion came to a halt for some time due to low rice prices, ample supplies and the difficulty of recovering *operation and maintenance* (O&M) fees, let alone the cost of construction (Philippine Economic Association 1934).

Following World War II and Philippine independence in 1945, the Huk Rebellion (1948-1954) in Central Luzon (the major rice growing area of the Philippines) shifted attention from export crops to rice, and issues related to both land reform and irrigation development. The government began to focus on rice self-sufficiency. With the gradual closing of the land frontier, inducing investment in irrigation to increase land productivity can be seen as a clearly rational decision (Hayami and Kikuchi 1978).

Irrigation and Water Management Practices in Taiwan and the Philippines over the Past Half-century

As shown in the previous section, the two examples reflect relatively large differences in the general context within which irrigation has evolved, thus providing the opportunity to explore the social, economic and political environmental impacts on the ways irrigation has been managed. We will highlight management practices that have been adopted to increase water productivity.

Taiwan: 1960s Onward

Entering the decade of the 1960s, in Taiwan, approximately 40% of gross domestic product (GDP) came from agriculture and 50% of the labor force was employed in agriculture (Figure 3a). As has been the custom in the early stages of development, most developing countries have taxed agriculture to transfer resources for the development of the non-agricultural sector (Lee 1971). In Taiwan, this was achieved through the *fertilizer-rice barter system*, where the government controlled the supply of fertilizer.

Most of the arable land in Taiwan was irrigated and planted two crops of rice, but the irrigation systems were badly in need of repair. Initially, as a consequence of limited water control, it was necessary to plant only rice in the paddy fields. Soon, however, the restoration and improvements in the irrigation infrastructure described below facilitated the production of a wide variety of crops, though rice remained dominant.

Basically, the structure of irrigation management in Taiwan has been one of a collaborative relationship between groups of farmer-irrigators and technical support staff combined initially into an Irrigation Committee, and subsequently (by 1956), into an Irrigation Association (IA). In principle, the farmers control the workings of the technical staff through a process that has changed over time (More on this is explained in later sections). While reflecting on this principle, the actual relationships are very complex, vary among the IAs and have changed significantly over time. The structure differs markedly from that found in many other countries. There is no central irrigation agency, such as the National Irrigation Administration (NIA) in the Philippines, the Royal Irrigation Department in Thailand, and the various State Irrigation Departments in India. Each IA has been, to a considerable extent, a 'self-contained' unit, subject to some regulatory oversight by a central agency, the Water Conservancy Bureau, and with technical support from the Sino-American Joint Commission on Rural Reconstruction (JCRR), which recently transformed into the Council of Agriculture. We describe the evolution of water productivity improvement in the country from the perspective of the intent of the programs that have been implemented, even though the degree of implementation is not uniform among the IAs.

To consider this pattern and its meaning for *water productivity*, we will consider three major events: the *land consolidation* program, the implementation of *rotation irrigation,* and the *adjustment to entry into the World Trade Organization (WTO)* including *water transfer*.

Land consolidation

The Land Consolidation program was a ten-year program initiated in 1961. The major objective of the program was to increase production efficiency, but it had a secondary effect of providing physical infrastructure that made water management (both irrigation and drainage) easier. The program consolidated the fragmented holdings into single reshaped units which were then provided with direct access to an irrigation channel, a drainage channel and to a path or road. An elaborate process of evaluating the productive capacity of each fragmented parcel, and then reallocating a parcel of equivalent productivity, combined with improved infrastructure, formed the basis for the program. The farmer's share of the cost of the program was reflected in the loss of 5% of the area of the fragmented holdings, based on the assumption that the increased efficiency and improved access to water, drainage and roads would more than compensate. In addition, the farmers paid part of the cost of the infrastructure with long-term loans.

The program resulted in increased efficiency of the agricultural activity and provided the ability to intensify cropping. There was no significant change in the water used per hectare, but there was a 'saving' in terms of the increase in water productivity.

Rotation irrigation

The second major development, the *rotation irrigation program*, was initiated in the same general period as the *land consolidation program*, and basically continues to this day. It followed a severe drought during which water was rotated among the users and it became apparent that production could be maintained with less water for irrigation. Prior to the program, irrigation was primarily continuous flow. Water was applied to keep the fields flooded, and there was both field-to-field and channeled flows. Head-end irrigators were advantaged, both in delivery and protection from excessive flooding. With both *production* and *equity* considerations in mind, the government proposed a program of rotation irrigation, a type that required both significant technical infrastructure (both physical and institutional), and close collaboration among the farmers and between the farmers and the operating staff. Implementation was fostered by a *national extension program* with funds to pay for much of the technical infrastructure and other forms of assistance to the water users. During this same general period, the Irrigation Committees were converted to Irrigation Associations, with a Representative Assembly and elected Chairman[3] and the number of associations was reduced to 26 from the 40 Irrigation Committees[4].

[3] This introduced opportunities for significant political activity, with both positive and negative aspects.

[4] The basic rationale for the reduction was to facilitate management of the water sources, by grouping all those associations that were served from the same water source (except for those on the largest rivers). However, when the rotation irrigation program was adopted, it also had the effect of providing a sizeable association that could support the increased number of technical staff.

The *rotation irrigation program* has been described in detail in a number of publications (Chin 1961; Ko and Levine 1972; Wen 1980), but briefly, the farmers essentially have complete control and responsibility for the distribution of the water within an area of approximately 150 ha (Small Group Area). The IA staff is responsible for ensuring that the allocation to subunits of that area (usually about 50 ha each) is in accordance with the IA rules.

When the supply of water is adequate, allocation of the water to various parts of the IA service area is based upon prior water rights, some of which were associated with earlier systems merged into the IA. Management of the water delivery to the Small Group Area is of a 'default upward' character (Levine 1991).

When there is a significant water shortage, generally in the order of 25% of normal, the original water rights are abrogated with agreement among the farmers in the Small Group Area, and allocation decision is shifted to the next higher level of control (~500 ha); irrigation allocations to the component areas are then based upon technical rules. Increase in the size of the control area permits the more equitable sharing of the water shortage, as well as making more efficient use of the scarce water. This pattern of movement of allocation control upwards continues, and may encompass the entire IA if water availability worsens. When the supply increases, control reverts downwards. While the allocations have a technical base, actual control of the delivery to the individual farmers remains in the hands of the farmers[5], though they may hire a common irrigator to do the actual irrigating, thus minimizing potential for conflict. This close relationship between the farmers and the IA staff, and the 'ownership' of the IA by the farmers, is illustrated by an experience in the field by Gilbert Levine (one of the authors of this report). In one of the Small Group Areas, the Chief Engineer of the IA, an IA Irrigation Attendant from the local Working Station, a senior engineer from JCRR and the author (Levine) were discussing the water measurement practices, when an angry farmer came to the group, singled out the Irrigation Attendant[6] and demanded that he do something about his down-channel neighbor who had blocked the channel, resulting in flooding of the complaining farmer's field. It was clear that the farmer knew who had the responsibility to ensure the system was working, and that this person was responsible for the actions of the down-channel neighbor. The fact that the farmer's fee paid the staff salaries was also clear to the technician.

Rotation irrigation, as practiced in Taiwan, generally resulted in substantial physical water saving, but of variable amounts and with significant costs. Beyond the costs associated with the land consolidation program, there were additional costs for measuring structures and gates, which were partially subsidized, and for the increased staff. Table 1 shows the change in O&M costs as a result of implementing rotation irrigation in six IAs; all IAs had increases above 100%. The water saving was variable but generally in the order of 25%. The reason for the increased costs was the increased technical capacity (Table 2), which is designed to meet the needs of severe water shortage, but is in excess most of the time. Of the total cost associated with *rotation irrigation*, approximately two-thirds was borne by the farmers and the remainder by the government.

It should be pointed out that the Taiwan systems generally operated at a RWS (quantity delivered divided by the quantity required by the plant) of between 2 and 2.5[7], which indicates that significant water savings could be achieved at increasingly higher costs. For example, during a severe drought in the Yun Lin IA, to approach a RWS close to 1, the IA staff monitored the *parshall* measuring flumes at the 50-ha irrigation area levels night and day; the main channel

[5] For a more complete description of the farmer roles, see Lam 1996.

[6] The Irrigation Attendant carried a tall pole with a pennant, which was visible throughout the paddy area. It was clearly intended to ensure that the farmers could locate him when needed.

[7] Water deliveries generally approximated 1,800 mm and water 'required' (evapotranspiration plus essential seepage) approximated 700 mm. Factoring in some loss in channels results in the suggested RWS between 2 and 2.5.

TABLE 1. Change in O&M costs as a result of implementing rotation irrigation in six Irrigation Associations (IAs).

Irrigation Association (IA)	Maintenance (TWD/ha)		Operation (TWD/ha)	
	Before	After	Before	After
Tao Yuan	149	176	6	68
Mei Chi of NengKao	39	74	14	17
Nan-hung of NengKao	40	64	8	18
Tai-li-wu-pei of Tou-liu	390	722	42	77
Hu-tze-pi of Tou-liu	264	701	46	66
Taliao of Kaohsiung	50	79	4	34

Source: JCRR 1968.
Notes: Costs are rounded to the nearest Taiwan New Dollar (TWD); Before – data are average values for the five years prior to the implementation of rotation irrigation; After – data are average values subsequent to the implementation of rotation irrigation.

TABLE 2. Personnel changes due to rotational irrigation.

Irrigation Association (IA)	Technician		Ditch tender	
	Before	After	Before	After
Tao Yuan	27	77	0	12
Mei Chi of NengKao IA	4	4	0	0
Nan-hung of NengKao IA	2	2	0	0
Tai-li-wu-pei of Tou-liu IA	1	3	2	6
Hu-tze-pi of Tou-liu IA	1	2	2	2
Taliao of Kaohsiung IA	6	7	0	9

Source: JCRR 1968.
Notes: Before - data are average values for the five years prior to the implementation of rotation irrigation; After – data are average values subsequent to the implementation of rotation irrigation.

was dredged to obtain maximum inflow to the system; when there was any flow in the drainage channels it was recovered through pumping; and the farmers used common irrigators to avoid personal conflict (Levine 1983). Production was approximately 95% as normal with approximately one-half of the customary supply.

It is also important to note that, in addition to the educational and financial aspects of the implementation process, there was a significant political commitment at the local as well as the national level. In a number of cases, head-end farmers objected to the implementation of rotation, and force was used to compel compliance. In more than one instance these resisters were jailed, usually only for a day or two, but it was sufficient to indicate that this was a government priority[8].

As indicated earlier, while the *rotation irrigation program* was designed to be applied throughout Taiwan, not all IAs fully implemented the program, and in those IAs that did not implement it there was little change in water use. The primary reason for the variability in implementation was the relative abundance of the water supply, often based on groundwater (Lam 1996).

[8] Personal communication to Gilbert Levine (one of the authors of this report) by a group of senior IA engineers in 1969.

Further institutional changes

The *rotation irrigation program* lasted essentially as described for approximately 15 years, with an increasing politicization of the election process for the IA Chairman. This, and increasing complaints about the IA cost, irrigation service and falling farm incomes relative to non-farm incomes (Levine et al. 2000), resulted in a five-year trial consisting of closer supervision of IA operations by the government, appointment of the Chairmen by the government and a reduction in the number of IAs to 17. There was an improvement in performance, modest reduction in IA staff and a small reduction in the user contribution to IA expenses. However, concern developed that the IAs were becoming increasingly technocratic and susceptible to a lack of interest on the part of the government. At the end of the five-year period, the IAs were permitted to return to the prior arrangements, with a modified representative assembly (Small Group Leaders, rather than the farmers), an elected Chairman and more stringent rules for IA operation.

Notwithstanding the modest improvements in service, the financial position of the farmers worsened, in comparison to the non-farm sectors. As a result, the government increased the subsidy to the IAs until (by 2000) the farmers paid no irrigation fee to the IA and many of the IAs were looking for other sources of income. As stated earlier, the combined *land consolidation* and *rotation irrigation programs* did result in a physical water saving of approximately 20-25%, but part of this 'saving' was due to the reduction in the paddy rice cropped area facilitated by the programs. By 1993, the reduction in paddy rice area was approximately one-third (Annual Statistical Data, 1973-1994 (Taiwan Irrigation Associations n.d.)). At the field level, however, the average seasonal application per hectare for paddy increased by approximately 5%. This suggests that irrigators will reduce their managerial effort to the least costly rate of use when the supply is available, even when the physical and managerial infrastructure for more efficient operation is in place.

The removal of the farmer fee had the additional effects of reducing farmer interest in contributing to the voluntary system maintenance and increasing the social distance from the technical staff (Ko 1997). It should be noted, however, that the physical water saving was also a reflection of the increasing per hectare yield that permitted the reduction in area while still meeting the national target for rice production.

Entry into World Trade Organization, water rights and water transfer

The entry of the Taiwan into the World Trade Organization (WTO) introduced a new and significant element into the water management equation. The requirement to enter into the international rice market through international purchases of rice accelerated the need to reduce domestic production.

At the same time, there was increasing pressure to transfer water from agriculture to non-agricultural uses. According to the prevailing *water law*, water is permitted to be transferred from water-rights holders to other users whenever the need is clear and there is agreement on compensation. However, in the event of extensive drought, the government steps in to perform emergency water transfers by suspending water rights. Huang et al. (2007) provides examples of both these types of transfers. In the case of a normal transfer from the Changhwa and Yunlin IAs to the Formosa Petrochemical Corporation, no agreement could be reached on compensation after a year of negotiation. The Central Region Water Resources Office then stepped in and set the price. In the second example, an emergency transfer of water from the Taoyuan, Shimen and Sinchu IAs to domestic and industrial users took place from the period 2002 to 2006.

Additionally, questions were raised by the WTO about Taiwan's subsidy to agriculture, including payments to the IAs. This combination of (i) increasing political pressure to reduce subsidies, (ii) increasing pressure to transfer water from the agricultural to the domestic and industrial sectors, and (iii) increasing recognition that paddy culture had significant impacts on environmental services, prompted efforts to evaluate the net benefits from the ecological services provided by paddy culture and to consider those in justifying continued payments to the IAs. Recent studies of two IAs in northern Taiwan have evaluated the economic effects of water transfer, including the loss of environmental services as well as the loss in production (Chang and Boisvert 2010). A comparison of these losses with the compensation payments made by the government suggests that the payments still exceed the losses significantly. If this conclusion is borne out by additional more comprehensive studies of other parts of Taiwan, there will not only be increased pressure to transfer additional water from the agricultural sector, but also increased pressure on the IAs to increase the efficiency of their operations and to generate income from sources other than agriculture.

Rural transformation

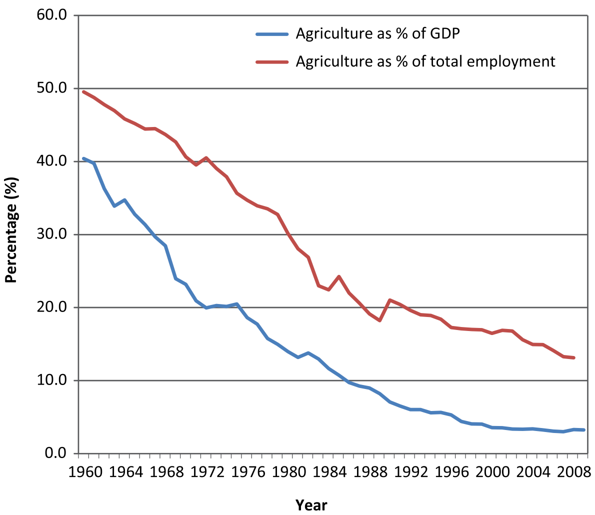
Finally, we emphasize the important role that the non-farm sector has played and the effect this has had on farm and irrigation policy. As economies develop, the share of agriculture in GDP falls and the labor force in agriculture falls more slowly (Tomich et al. 1995). This is shown for Taiwan in Figure 3a. In the early stages of development, agriculture is taxed, but as the non-farm sector grows, first the agricultural taxes are removed and subsequently agriculture is subsidized. The switch from taxation to subsidization is common to all agricultural imports and exports, although imports are always less taxed or more protected (Lindert 1991). The rise in the non-farm economy was extremely rapid in Taiwan. In 1970, the tax (*fertilizer-rice barter system*) was removed. By the mid-1980s only 10% of the labor force remained in agriculture. Farmers no longer paid irrigation fees. The IAs were gaining political and economic strength through subsidies, and Taiwan, following Japan, was rapidly becoming a nation of part-time farmers. Today, there is a focus on ecosystem services provided by paddy rice and the transfer of water to industry.

Philippines: A Half-century of Irrigation Development and Management Reform

In 1960, irrigation in the Philippines was predominantly through river-diversions, primarily for rice. The rice area irrigated was close to 1 million hectares (Mha) or approximately one

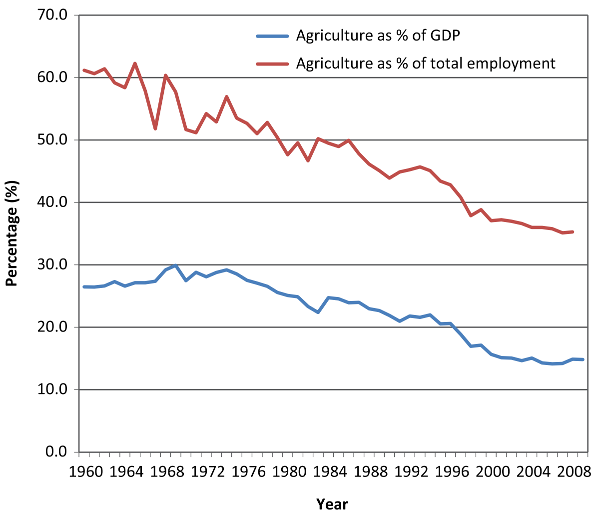
FIGURE 3. Trends in the percentage of the labor force in agriculture and the percentage of agriculture in GDP from 1960 to 2008 for (a) Taiwan, and (b) the Philippines.

(a)



Source: Huang-hao Chang, National Taiwan University (data for Taiwan).

(b)



Source: Christina David, Philippine Institute for Development Studies (data for the Philippines).

quarter of the total rice area (Rose 1985). The farm size was typically 2 to 3 ha. However, in the most densely populated area of the Philippines, the Illocos, farms were typically only 1 hectare in size. Ancient communal irrigation systems called *zangheras* were noted for their excellent water management (Lewis 1980).

As of 1960, 60% of the labor force was in agriculture accounting for 30% of GDP (Figure 3b), percentages which were not very different from Taiwan (Figure 3a). Most of the farmers were tenants, who, in the case of rice, paid 50% of the harvest to landlords.

The discussion in this section is divided into five subsections dealing with the development of the irrigation sector in the Philippines. It is a story of both success and failure and contrasts sharply with the development of irrigation over the same period in Taiwan. The story brings focus to the preconditions for success.

The drive for self-sufficiency

The 1960s marked the beginning of the drive for self-sufficiency in rice, which, with a rapidly growing population remains an elusive target even today. According to the current Aquino administration, they will phase out imports completely in 2013. Economists have questioned this priority given the diverse environment of an island economy (Dawe et al. 2006), which is to say that importing rice is not a bad thing. However, politicians consistently express the need to avoid reliance on imports from an unstable world rice market.

The establishment of the National Irrigation Administration (NIA) in 1964 brought 79 National Irrigation Systems (NIS) serving 217,000 ha under one agency (Panella 2004). At the time there were 771 Communal Irrigation Systems (CIS) (mostly 100 to 200 ha in size) totaling 393,000 ha and an estimated 2,450 pumps/tube wells covering 51,000 ha (Panella 2004).

Ferdinand Marcos, elected for the first time in 1965, was to become NIA's strongest political supporter. In 1966, Marcos appointed Alfredo Junio, Chair of the University of the Philippines, College of Engineering, as administrator of the NIA. Junio served as administrator until 1980, and it was under his leadership that the NIA developed into a highly regarded irrigation bureaucracy.

NIA is divided into two units, *construction,* and *operation and maintenance* (O&M). For the viability of the NIA in this period of expansion, the construction was seen as being more critical than O&M. The primary focus was on obtaining loans from international donors, in particular, the World Bank (WB) and the newly established Asian Development Bank (ADB) (1966). In the early stage of its development, the NIA relied heavily on the support of the United States Bureau of Reclamation (USBR) for the designing of new multipurpose systems and the training of NIA personnel.

At the same time, it should be recognized that the primary experience of the USBR was in the design and construction of major physical works, including dams, major channels, etc., in the western part of the United States, which is a dry area. The design and implementation of the smaller irrigation systems were generally the responsibility of other organizations, usually irrigation districts with their own governing boards, managers and technical staff. Water rights were typically associated with individuals and water delivered 'on demand', and the farms were relatively large in comparison with that in the Philippines. As a result of this experience and with the emphasis on new construction, the focus of the training was on the development of the organizational infrastructure, personnel to carry out the planning of large multi-purpose dams and maintenance of the physical structures. System operation was probably addressed only in theoretical terms with the details left to the NIA and staff. Issues of water rights, user-controlled irrigation districts or other aspects relating to the use of the water were not likely to be part of staff training. This is in sharp contrast to the situation in Taiwan, where the emphasis was on improvements in irrigation at the user level and on the need for a close relationship between the farmer and IA staff.

Farmers were expected to pay the cost of O&M, but normally the collection of fees only covered about half of the requirement for proper maintenance. Thus, from the beginning, the operations of the NIA were heavily subsidized by the Philippine Government despite later efforts to make NIA financially self-reliant.

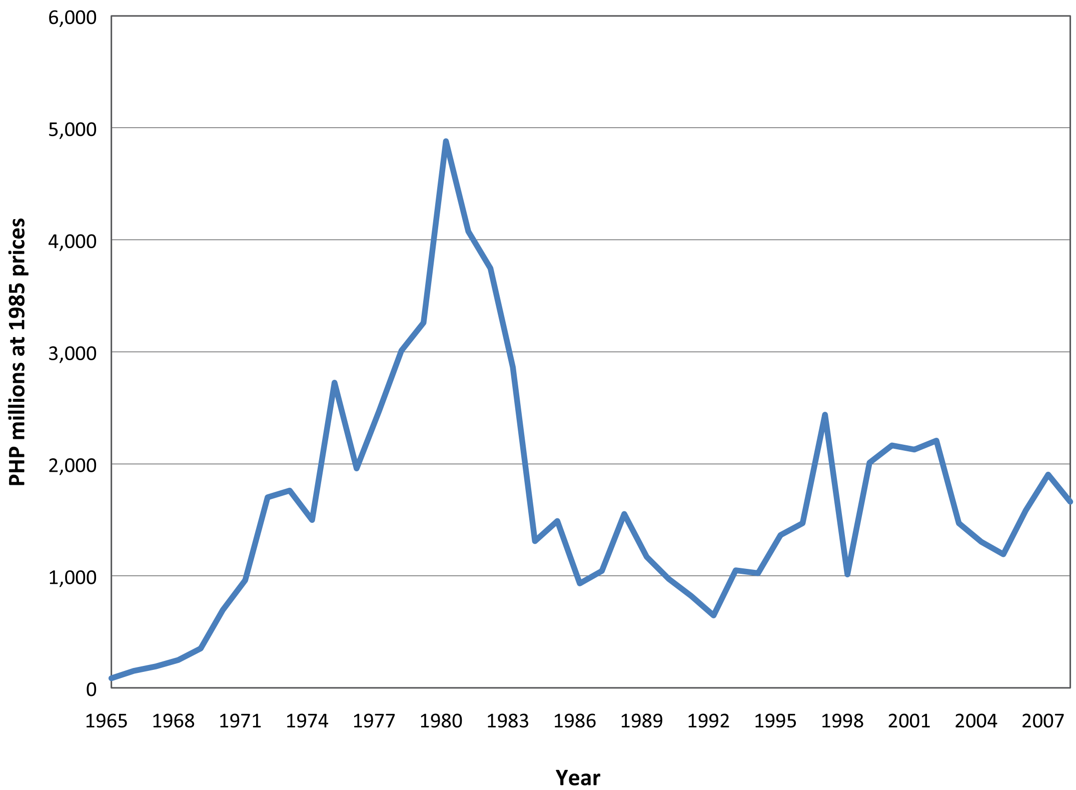
In 1972, the rice sector of the Philippines, and that of many other Asian countries, experienced what has come to be known as an *el nino.* The heavy monsoon rains and the flooding resulted in a 20% loss of the main crop in Central Luzon. Elsewhere, in parts of the Philippines and the rest of Asia experienced drought. World rice prices skyrocketed and there was a shortage of rice from exporting countries such as Thailand. In 1973, Philippine rice imports were the highest in more than a decade and the country was forced to import white corn to mix with rice.

This 'shock' to the rice sector in the Philippines had the effect of reinforcing the drive for self-sufficiency. In the years immediately following: (1) NIA continued its expansion of the irrigated area with financial support from international donors, and with funding for new projects reaching a peak in 1980 (Figure 4); (2) the government, complementing the development of irrigation, launched the 'Masagana 99' program to promote modern rice technology and provide farmers with low interest loans, many of which were never repaid; and (3) a program was initiated to involve farmers directly in water management below the main turnout commonly referred to as *irrigation management transfer* (IMT). It is to IMT that we now turn our attention.

Early implementation of participatory irrigation management in the 1970s and 1980s

There was a growing concern in the 1970s that water resources for irrigation were being 'poorly managed'. Depending upon the emphasis given by the individual stakeholder (including farmers, irrigation administrators, politicians, etc.), good management would include issues such as productivity, equity and financial viability. In the early 1970s, two research studies were conducted by the International Rice Research

FIGURE 4. Trends in public expenditure on irrigation investments, 1965-2008 (PHP millions at 1985 prices).



Source: David and Inocencio 2011.
Note: PHP = Philippines Peso

Institute (IRRI) in collaboration with NIA. The first, inspired by the experiences of Taiwan, involved a pilot study comparing rotation irrigation with continuous flooding during the dry season at three locations in the Upper Pampanga River Irrigation System (UPRIS) in the 1974 dry season (Wickham and Wickham 1974). Yield per hectare and yield per cubic meter of water showed no significant difference between rotation irrigation and continuous flooding at all three sites. As noted in the previous section on Taiwan, for a normal year this is what one could expect.

The real impact of *rotation irrigation* (Taiwan style) occurs in a drought year when the infrastructure and the capacity to manage water make it possible for more effective use of limited quantities of water. NIA initiated a trial of the Taiwan-style rotation structure, with 50-ha areas and 10-ha units. No results of the trial were published, but it was not continued or replicated. One would have to conclude that the cost of making the required changes in both the physical and institutional structures was too great for whatever benefit that could be anticipated. In contrast to Taiwan, in the dry years, NIA found that cutting off delivery to the tail-end of the system made it easier to manage and allocate the limited water supply.

In the second research study (Valera et al. 1975), IRRI obtained permission from NIA to operate Lateral C of the Peñaranda River Irrigation System in Central Luzon with a service area of close to 6,000 ha. Randolph Barker (the lead author of this report) was involved in this project. The objective was to address the ubiquitous head-tail problem. The plan was simple. The tail-ender farms would plant first, and during the growing season water would be provided to the tail-end four days in the week and to the head-end three days in the week. The main canal was divided into four sections and the sub-laterals were monitored by four staff to ensure that farmers did not interfere with the plan. The son of the mayor of the local town owned land at the head of the system and objected to this plan strenuously. By convincing him that his yields would not suffer, the project was allowed to move ahead.

Table 3 compares the dry seasons of 1974 and 1975, following implementation of the plan. While there was a slight gain in yield in all four sections, the area irrigated and the production of rice rose sharply in section 3 and 4 of Lateral C. Some years after completion of the study, we talked with a NIA water-master who was familiar with the project. What had happened since? Was our plan still being adopted? He simply said, “same mayor, same son.” They were back to the old system.

A presidential decree in 1974 (PD 552) greatly increased NIA’s financial responsibility and purview over irrigation activities (Panella 2004). The first step in the improvement of water management was the adoption of *participatory irrigation management* (PIM) as a strategy to manage the *communal irrigation systems* (CIS), many of which the NIA now had responsibility for. The basic concept of the new approach was for the government to provide financial

TABLE 3. Area planted and yield of rice in the dry seasons of 1974 and 1975 in four sections of Lateral C, Peñaranda River Irrigation System.

Section		Total irrigable area (ha)	1974		1975		Increase in production 1974 versus 1975
			Area planted (ha)	Yield (t/ha)	Area planted (ha)	Yield (t/ha)	(%)
Upper	1	1,220	1,185	2.6	1,110	3.0	8
	2	1,135	1,055	2.4	1,115	3.0	32
	3	1,998	1,237	2.2	1,699	2.6	62
Lower	4	1,422	402	2.1	871	2.3	137

Source: Valera et al. 1975.

and technical assistance, but this had to be in a manner so that it would maximize the farmer's participation in the planning, design and construction of the system, as well as operation and maintenance (Bagadion 1988).

In fact, the focus on PIM was, in large measure, due to the establishment of the *communal irrigation committee* (CIC) to assist the NIA (Panella 2004). The CIC is perhaps unique in the annals of irrigation development. It consisted of a number of academic stakeholders representing a range of expertize and disciplines, and NIA personnel. The CIC recognized that there were a number of communal systems being successfully managed by farmers, such as the *zanjeras* in Ilocos Norte (Lewis 1980; Siy Jr. 1982), and a number of research studies were undertaken to identify both the opportunities and constraints in the PIM approach.

One such study by De los Reyes and Jopillo (1988) compared 24 systems where PIM had been implemented with 22 non-participatory systems. The cost of implementing PIM was only 3% of the total cost of construction. Mean rice yields were approximately half a tonne higher (3 versus 2.5 tonnes) for systems under PIM. However, there was recognition of considerable scope for improvement. By 1984, the NIA had learned to implement this new approach efficiently on a nationwide scale. In fact, the NIA gained international recognition for its innovative approach to irrigation management (Korten and Siy Jr. 1988).

Institutionalization of participatory irrigation management

Moving the focus of PIM away from the communal to the national irrigation systems posed a number of problems. For example, first, there was a lack of alignment of stakeholders (NIA personnel, farmers and landowners, politicians and WB) with the objectives of the reform. Second, there was little actual involvement of the farmers in the planning, design and construction of the irrigation system. The focus was on shifting responsibilities to the IAs. A three-stage process was devised for the turnover. Stage I required routine maintenance to be carried out by the IA in return for a 2% share of the fees collected. The Stage II contract gave the IAs full responsibility for O&M of canals and a larger share of fee collections. Stage III contracts gave full responsibility to the IAs for management of the entire system. Although, later, at the request of WB, these contracts were renamed, type I, II and III, and there was no intention that IAs would graduate from stage I to III. The NIA employees, worried about their future jobs, applauded WB's insistence, under the first rehabilitation loan, that for type II contracts the NIA be given responsibility for O&M (Panella 2004). Subsequently, however, NIA staff concentrated on fee collection at the expense of O&M, although the irrigation service fee collections continued to be less than 50% of O&M costs.

Next, there is the question of how the irrigation systems operated on the ground level. Here, it is useful to see the contrast between the operation of the Taiwan and the Philippine systems. One may regard the Taiwan approach to management as semi-authoritarian, in that administration and the ability to demand compliance trumped politics at the local level. In the Philippines, it was the opposite.

In the 1990s, Oorthuizen (2003, 2004) undertook a detailed study of the adoption of the NIA turnover program in two IAs, one each in zones 1 and 2 of the fourth district of UPRIS. Once again, the issue revolved principally around the distribution of water resources during the dry season, the period of water scarcity. Oorthuizen notes that, two evaluation studies conducted in the early 1990s claimed that the turnover program had resulted in increased fee collection, reduced personnel costs, a larger irrigated area and higher dry-season yields. Oorthuizen argues, however, that these studies overlooked the implementation of the turnover policies in different irrigation systems and how these policies are given shape at the grassroots level.

When the IA in zone 1 of the UPRIS first experienced water scarcity in the dry season of 1983-1984, politicians became the central actors in water management, giving much time and effort to the allocation of water. With implementation of the NIA program, this had not changed. The situation in the IA in zone 2 was entirely different. The adoption of the NIA program was 'successful', but due in large part to the close family ties between NIA personnel and the village at the tail-end of the system. In general, it appears that NIA personnel tended to interact with a selected group of farmers in the IAs. Many farmers did not even know that they were a member of an IA.

1986 onward

It is perhaps a paradox that the end of the Marcos Administration (1986) and the advent of the more open society of the Aquino administration brought problems to the NIA. Junio, the long-time administrator of the NIA, retired in 1980, and in 1986, another champion of NIA reform, Bagadion, was gone. The leadership became politicized, a series of NIA administrators, often with no knowledge of irrigation, served as directors for three years or less.

A decline in the capital growth of the NIA led to a decline in the numbers of NIA personnel. In the late 1970s, *project personnel* reached a peak of 20,000, but from the 1990s onward this number was only one to 3,000. *Operations personnel,* reaching a similar peak of 20,000, declined more slowly to the present level of 7,000. This led to 'deferred maintenance'. Routine O&M became neglected as NIA staff concentrated on irrigation service fee (ISF) collections to maintain the financial viability of the NIA. The willingness of the WB and ADB to provide relatively frequent rehabilitation loans has supported the practice of deferred maintenance globally. Under many situations, the policy of deferred maintenance has been a rational response to the combination of farmer adjustment to declining service, politics and continuing availability of development bank rehabilitation loans (Levine 1986). However, the need for rehabilitation of some systems in the Philippines (that have had no O&M in less than a decade), raises questions not only about the lack of maintenance but also about the quality of initial construction.

WB and ADB have continued to press for the turnover of O&M responsibility to irrigator associations at the secondary and tertiary levels, not just in the Philippines but elsewhere (Mukherji et al. 2009)[9]. In the Philippines, training programs were set up by the NIA for the IA leaders, but often there was very little interaction between the IA officers, board and the average farmers, many of whom, as noted above, didn't know they were members of their respective IAs.

Three surveys were conducted to assess the performance and factors associated with 'good performance' of the IAs (NIA 1999; Fujiie et al. 2005; Araral 2009). While factors such as water scarcity, size of IA and nearness to market affected 'performance', performance was not measured in terms of an increase in water productivity or greater equity but rather by factors such as maintenance and fee collection. The case studies by Valera et al. (1975), in the section, *Early implementation of participatory irrigation management in the 1970s and 1980s*, and Oorthuizen (2003), in the section, *Institutionalization of participatory irrigation management*, give a better sense of the constraints associated with PIM and the performance of the IAs at the grassroots level.

Obtaining loans from WB and ADB required compliance with their IMT programs. Thus, the Philippines did not experiment with other institutional forms for managing water. In China, for example, the IA model of WB was being adopted in some irrigation systems. However, China was also adopting a variety of contract arrangements (Shah et al. 2004). To evaluate these arrangements, research was conducted by the Center for Chinese Agricultural Policy in several surface irrigation systems in north China (Huang et al. 2008). It was identified that the best results in terms of water saving at village/ association level were obtained by contractors provided with incentives.

Almost all of the Philippine irrigation literature deals with gravity irrigation systems, i.e., the

[9] The Participatory Irrigation Management (PIM) program was replaced by the Irrigation Management Transfer (IMT) program.

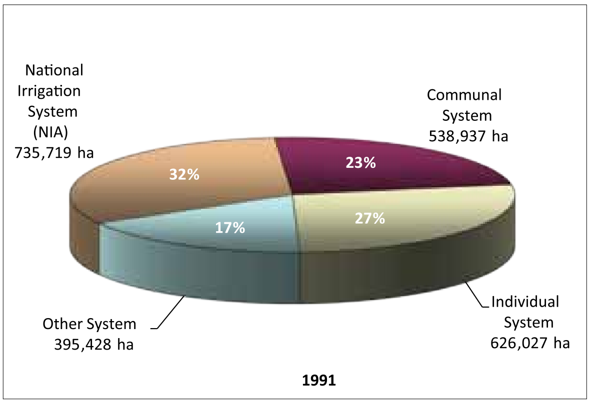
national irrigation systems (NIS), the communal irrigation systems (CIS) and the NIA. In the last two decades, the area irrigated by gravity irrigation systems has remained fairly constant at around 1.3 Mha. However, the total irrigated area has continued to rise (Figure 5). This has been due to the sharp increase in the area irrigated by low-lift pumps which, since the 1990s, has occurred not only in the Philippines but also elsewhere in Asia. This is frequently referred to as the *groundwater revolution* (Barker and Molle 2004), a period of groundwater exploitation and in much of the semiarid regions there is overexploitation (Shah 2009).

As David notes, much more information is needed to find out whether, and to what extent, pumps are being used in the wet and/or dry season, among tail-enders and for crops other than rice.

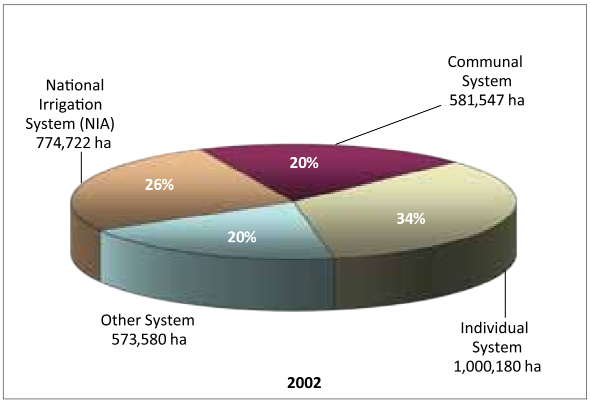
Competition for water from non-agricultural uses has been confined mainly to the urban areas, particularly Metro Manila and Cebu. Over the past two decades, water from the Angat Dam and Reservoir has been gradually transferred to meet the demands of Manila (Figure 6), apparently without compensation to farmers.

FIGURE 5. Distribution of irrigated parcel area, by type of main irrigation system in (a) 1991, and (b) 2002.

(a)



(b)



Source: Inocencio and Barker 2006.

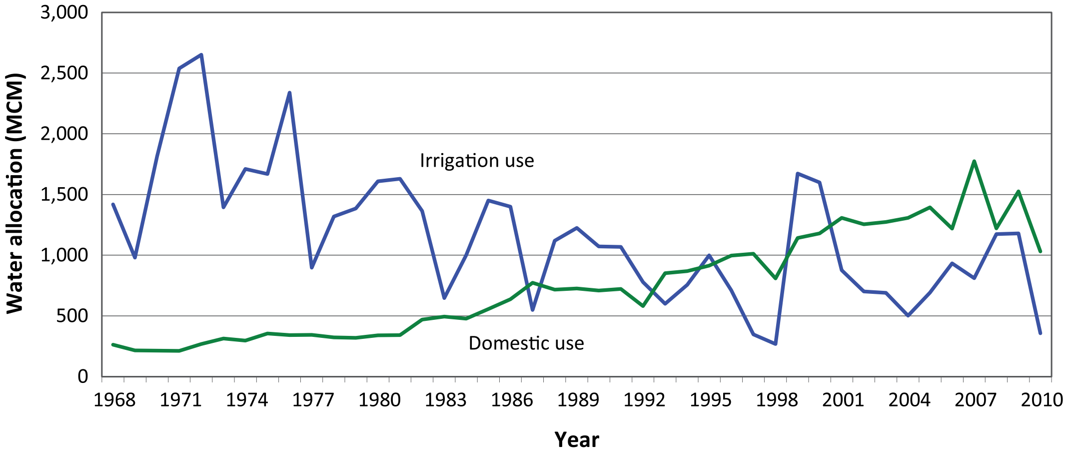
However, partly because it falls in the private sector, data on the area irrigated by pumps and their impact on production in the Philippines are not reliable. The 1991 and 2002 Philippine Census of Agriculture shows a sharp rise in irrigated area due to 'individual systems and others' (Figure 5), and much of this area is served by pumps. David[10] estimates that based on the 2002 Census of Agriculture, approximately 650,000 ha were irrigated by pumps. For about one-third of this area, pumps are used conjunctively within the NIS and CIS service areas. It is fair to assume conjunctive use does not imply conjunctive management.

Rural transformation

One of the most important factors in the development of Philippine agriculture has been the expansion of irrigation. This was made possible by loans from the international agencies such as the World Bank, some of whose policies we have examined in the previous sections. In 1960, there were 4.5 Mha of rice, of which an area of 1 Mha was irrigated. Today, there are 4.5 Mha of rice, of which an area of 3 Mha is irrigated. Rice yields have grown by more than 2% per annum. Despite this achievement, rice self-sufficiency remains an elusive target (Table 4).

[10] Christina David, Philippine Institute for Development Studies, is currently examining the various sources of data from the Census and elsewhere to arrive at a reasonable estimate of the area irrigated by pumps.

FIGURE 6. Angat Dam water allocation, 1968-2010.



Source: Government of the Philippines, National Water Resources Board, 2011.
Note: MCM – Million cubic meters

TABLE 4. Development in rice production in the Philippines, 1950-2008.[a]

Year	Paddy production (1,000 metric tonnes)	Paddy harvested area (1,000 ha)	Paddy yield (t/ha)	Population ('000s)	Rice self-sufficiency rate[b] (%)
1950	2,738	2,350	1.16	20,125	97
1960	3,801	3,235	1.18	27,087	96
1970	4,854	3,233	1.5	36,586	93
1980	7,782	3,468	2.25	48,151	102
1990	9,333	3,378	2.77	62,430	97
2000	12,148	3,967	3.06	77,688	88
2008	16,375	4,385	3.73	90,353	82
Growth rate (compound (%/year))					
1950-1960	3	3.6	-0.6	3	-0.1
1960-1970	2.8	0.1	2.7	3	0.3
1970-1980	5.7	1.2	4.5	2.7	1.3
1980-1990	2.1	0	2	2.6	-0.4
1990-2000	2.3	1.7	0.6	2.2	-1.8
2000-2008	3.7	1.2	2.6	1.9	-1
1950-2008	3	0.7	2.3	2.6	-0.2

Sources: **1948-1959:** Rose 1985.

1960-2010: Rice production, area and yield, import, export and milled rice production: United States Department of Agriculture (USDA) Production, Supply and Distribution (PSD) Online. Available at www.fas.usda.gov/psdonline/ (accessed on May 27, 2012).

Population: 1950-2010: Population Division of the Department of Economic and Social Affairs of the United Nations. World Population Prospects: The 2010 revision. Available at http://esa.un.org/unpd/wpp/index.htm (accessed on May 27, 2012).

Notes:

[a] Five-year averages centering on the years shown.

[b] Estimated as milled production / (milled production + import - export)

The problems would seem to lie outside of the rice-producing sector. At 2% per annum, population growth remains the highest in Asia. Furthermore, in contrast to Taiwan, the percentage of agriculture in GDP has been declining more slowly (Figure 3b), reflecting the slow growth in the non-agricultural sector. There is considerable debate as to the actual per capita consumption of rice in the Philippines, but it appears that it remains fairly high and stable while in most other Asian countries it is declining. This is related to the slow growth of the urban population and labor force where the substitute of other commodities for rice is most pronounced.

Conclusions

Based on our observations of the development of irrigation in two contrasting situations, in Taiwan and the Philippines, we draw some general conclusions. We believe that these conclusions apply more generally to situations found in much of Asian agriculture.

1. The determination of irrigation '*water saving*' is difficult because of the ambiguity of the term.
   - Even when the term refers only to a reduction in the physical amount of water used for productive purposes, the boundaries of the area of concern can significantly affect the conclusions that can be drawn. For example, water applied in excess of evapotranspiration will leave an irrigation system through percolation to the groundwater or through surface runoff; whether this water is a 'loss' to be 'saved' depends upon whether it is subsequently used productively, either by pump users or surface water users downstream.
   - Thus, any evaluation of real, physical water saving must encompass at a minimum, the entire watershed. This suggests the need for 'water accounting' at that level.
   - When water saving is defined as increasing the utility of the water supply, then the evaluation must be based on the benefit derived from its use. If, for example, the economic return from the water is increased through investment in improvements in cropping (better varieties, more valuable crops, etc.) effectively, water saving occurs. Even though the objective of the 'green revolution' was to increase yield (value of output) per hectare and not save water, the increase in *water productivity* over the past half century has come serendipitously largely through varietal improvement.
2. Physical water saving is unlikely to occur at the farm level, except when the available water supply is reduced. In evaluating the impact of changes in irrigation, '*water productivity'* is a more appropriate measure. *Water productivity* can be expressed in both *physical* and *socioeconomic terms.*
   - The Taiwan experience shows that even with strong physical and institutional infrastructure, the amount of water applied per hectare (often referred to as *irrigation* efficiency) does not necessarily change significantly. *The area under rice* has reduced over time, while *rice production has i*ncreased, as has *production of higher-value non-rice crops.* The financial and social costs of physical water saving, or reducing the amount of water diverted at the farm level, can be large. Increased financial investment, as well as increased time and effort and increased coordination among farmers are required.

- When these costs are sufficiently large, and where groundwater is accessible, farmers in large numbers will invest in pumps, as is occurring in the Philippines.

3. The extent of system-level operational management actually applied is a function of the available physical and institutional infrastructure, the available supply of water and political will.

   - In Taiwan, notwithstanding the infrastructure availability (both physical and institutional) to deliver measured amounts of water to the 50-hectare level (approximately 50 farmers), the full capability was generally used only in cases of severe drought.
   - The existence of the physical and institutional capacity in the IAs in Taiwan permitted inclusion of non-rice crops as the economy changed.
   - In the case of Taiwan, the objectives for exercising a high level of management during drought included <u>both</u> the maintenance of production and the equitable sharing of the burden of the water shortage.
   - In the case of the Philippines, even when there was the physical and institutional infrastructure to deliver water to sub-laterals and below, during drought, the NIA response to drought tends to be a reduction in the area served. Reducing the area served is assumed to reduce losses in water delivery, ease the workload on the system staff and maintain the water supply to the favored area (often a necessary political objective). Equity is not an operable objective and the tail-enders are typically the ones that are cut off. More recently in the Philippines, tail-end farmers are purchasing low-lift pumps to assure an adequate supply of water for the dry-season crop. The ability to obtain water on demand allows farmers the flexibility of growing crops other than rice.

4. The sociopolitical environment greatly influences the physical characteristics of the irrigation system, its institutional structure and the evolution of both.

   - In the case of Taiwan, the ‘Land to the Tiller’ program (in which one hectare of land was provided to each family in the rural population), followed by the Land Consolidation and Improvement program, coupled with the formation of farmer-governed Irrigation Associations, established an effective basis for the twin objectives of equity and productivity. Notwithstanding the un-centralized character of the irrigation sector (with no national irrigation agency), these objectives have been maintained to the present time.
   - In contrast, in the Philippines, areas with large landholdings with tenant farmers were conducive to government-managed systems, within a national framework. Production was a basic objective, but with financial viability of the irrigation agency as a major rationale for engaging the water users through water users associations. Given the sociopolitical conditions, equity was not an objective even where greater equity (i.e., resolution of head/tail-end problems) would have increased productivity. In contrast, in those areas where landholdings were smaller, farmer-managed communal systems developed and equity in water delivery was achievable.

5. International agencies can significantly affect both the incentives for improved water management and the ability to achieve improvement.

   - In the case of Taiwan, international agencies, such as the World Bank and the Asian Development Bank, had little or no impact on irrigation development. However, the USA-funded Sino-American Joint Commission on Rural Reconstruction

(JCRR), in collaboration with academic institutions in the country, was a major force in providing financial resources, the intellectual backstopping and incentives for improvements in irrigation at the sector level and also at the IA level. As a result, while the technological advancements mirrored those occurring more widely in the world, the evolution of the institutional infrastructure was ‘home-grown’. In fact, during the 1970s and 1980s, Taiwan was frequently used as a model for other countries, including the Philippines, to follow.

- In the Philippines, five international agencies, representing technical, intellectual and financial inputs played significant roles in the development and evolution of the irrigation sector. In the 1960s and 1970s, the United States Bureau of Reclamation (USBR), as part of the United States aid program, trained staff of the national systems in the planning, design and operation of ‘modern’ irrigation systems; the Ford Foundation fostered experiments in the strengthening of the institutional structures of the communal systems and in the introduction of similar structures into the national systems; and the International Bank for Reconstruction and Development (IBRD) (an institution of the World Bank Group), and subsequently, the Asian Development Bank (ADB) and Japan International Cooperation Agency (JICA), were instrumental in financing the construction of major elements of the national irrigation system in the 1970s and the 1980s, and in subsequently pressuring for the transfer of various levels of responsibility of O&M to farmer groups (so-called *irrigation management transfer* (IMT)), both in the national and communal systems.
- In the national systems, with pressure and incentives from the lenders, repeated efforts by the NIA since the 1980s to introduce *irrigation management transfer* (IMT) have met with little success. Fee collections have remained at around 50% of billings, and the willingness to provide loans for rehabilitation creates an incentive for *deferred maintenance*.
- In summary, while the lending agencies have been vital to the development of Philippine irrigation, certain aspects of their policies have been counterproductive to the twin goals of productivity and equity in the Philippine environment.

6. Economic development has both pull and push effects that impact on the irrigation sector.
   - The higher wages associated with industrial and commercial development draw labor from the rural sector. In the case of Taiwan, this had a number of effects on the irrigation sector. The immediate effect was to make it difficult for the water users and the IA system operators to exercise the relatively high-labor input that is characteristic of rice production. As a result, there was a reduction in the area devoted to rice production (partially from a shift to vegetable production and more recently from a shifting out of agriculture) and a reduction in the percentage of family income derived from rice farming. A consequence was the reduction in farmer involvement in the governance of the IA.
   - The higher costs associated with the more-developed Taiwan economy, the reduced profitability of rice production and the increased demands of the technical staff of the IA (both in serving the needs of the more varied cropping patterns and also as a consequence of reduced staffing) resulted in a shift from taxation of agriculture in the 1970s to a complete subsidization at the present time.
   - In contrast, in the Philippines, economic development was much slower with less economic pressure to alter the relationship between the government

and the water users. As indicated above, however, the external forces focused attention on the institutional issues, with a significant emphasis on obtaining a greater participation of the water users in payment for the system operating costs.

- Typically, when the share of agriculture in national GDP drops below 10 to 15%, subsidization of irrigation and other elements in the agricultural sector occurs. This point was reached by Taiwan in the early 1980s and is only gradually being achieved in the Philippines in the last decade. However, the Philippines has been subsidizing irrigation for some time due perhaps in part to the pressure to achieve self-sufficiency.

7. Recognition of the importance of irrigation in relation to the environment has grown since 2000, but is still limited.

   - In Taiwan, partly as a consequence of the country's entry into the World Trade Organization (WTO), and partly as a result of increasing interest in environmental issues by urbanites, the roles of irrigation in providing environmental services (positive and negative) have gained increased attention. Since payment for these services is not considered a subsidy, careful evaluation of the costs and benefits associated with these services can provide a reasonable basis for determining the appropriate level of payment.
   - In the Philippines, neither pressure from the WTO nor influence of the urban sector interest has reached the point of significant environmental concern related to irrigation.

Concluding Comments

Comparison of the Taiwan and the Philippine experiences suggests that a shift from a focus on physical *water saving* to one of *water productivity*, particularly if viewed in a basin context, would broaden significantly the perceived options for irrigation improvement. Instead of limiting the options to changes on-farm and to technical, and perhaps institutional, modifications to irrigation systems (many of which have high financial costs), a change in focus would provide more appropriate consideration to the prioritization of critical geographic areas, the roles of cropping interventions, financial incentives, political factors and to the impacts on the environment. The comparison between the two countries also suggests that a failure to adequately address issues of equity in design and/or in implementation of water delivery is a major factor in the search for '*real water savings*' and gains in *water productivity*.

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