RESEARCH ARTICLE

Current Challenges in Agricultural Water Resource Development and Management in the Philippines

Arlene Inocencio
De La Salle University, Manila, Philippines
arlene.inocencio@dlsu.edu.ph

Randolph Barker
Cornell University, New York, United States of America

Abstract: There is a growing concern in the Philippines and elsewhere over what some have termed a "water crisis"—too little or at times too much water. We first discuss the historical context of Philippine irrigation development and management. Then we discuss the trends in irrigation development—public and private investment, national and communal systems, and new and rehabilitation projects. We note the rapid increase in private investment based on the agricultural census, mostly pumps and shallow tube wells, and the increase in investments on communals in the last decade. With the recurring and persistent problems on planning and investment, design and management, and operation and maintenance, we call for the rethinking of the way we develop and manage our agricultural water resources. Despite all the concerns, there are paths to improving water management and increasing water productivity, some of which are currently being pursued. We conclude, however, that climate change will make it difficult to achieve food security without continued reliance on rice imports.

Keywords: irrigation investment, planning and design, operation and maintenance

JEL Classifications: Q18, Q15, Q14, O31, H54, Q54

Much has been written about the emerging water crisis in the Philippines (Rola, 2015; David, 2003; Rola, Francisco, & Liguton, 2004; Oorthuizen, 2003). There are many who believe that the solution to the problem lies in improving the efficiency of water management in agriculture. There is a good reason to believe this as agriculture accounts for more than 80% of the total water use (Inocencio, Elazegui, Luyun, & Rola, 2018).

The rapid expansion of irrigated area through either construction of surface irrigation systems or exploitation of groundwater has, for the most part, come to an end. That is to say, developing more of the utilizable water resources is costly. The key issues now facing agricultural water development in the Philippines are: (a) given water scarcity, how to increase the productivity of existing water resources, and (b) how to respond to climate change. This initial overview article describes the development of water resources over time and the remaining challenges and concerns.

Historical Overview

In what follows, we describe the development of irrigation and water management in four chronological time periods. In each period, we identify the dominant external events and how they relate to internal Philippine events.

Pre-NIA: 1900–1960

Communal irrigation. Before 1900, under Spanish rule, there were so-called *friar lands* owned by the Church and managed with hired labor. There were also communals, or very small gravity irrigation systems built, operated, and maintained by farmers individually or in small groups (Oorthuizen, 2003; David, 2003). There were also plantations of crops other than rice.

One of the best known of the communal systems are the *zanjeras* of the Ilocos region often cited as an example of good cooperation and management. However, Lewis (1980) painted a different picture. Ilocos Norte was an area of extreme poverty and population pressure. Ilocano farmers migrating to the Cagayan Valley, faced a very different physical and socio-economic environment to which the *zanjera* model did not apply. Today, communal systems of various shapes and sizes (mostly 100 hectares or less) and varying degrees of government support account for about 34% of the total irrigated area.

American and Japanese occupation. Under the American occupation, there was a slow but steady expansion of irrigation facilities prior to the second World War. The government began to take a more active role in irrigation. In 1912, Act No. 2152 was passed transferring operational control of irrigation systems to the Irrigation Division, Bureau of Lands (David, 2003). This act was significant because it attempted to integrate planning, design, construction, and operation and maintenance (O&M).

However, during the American occupation, the agricultural economy of the Philippines was dominated by plantations of principally export crops—sugar, copra, abaca, tobacco, and timber. During the short-lived Japanese occupation, the plantation land ownership was maintained. After the war, aided by the Laurel-Langley Agreement (1955-1974) which eliminated tariffs on sugar exports to the US, the Sugar Block became the dominant political power. There seemed to be no urgency about rice production and irrigation. However, with the rapid growth in population of over 3% per annum, the highest in Asia, by the 1960s this was about to change.

Early Years of NIA: 1960–1985

An initial step in the so-called *green revolution* was the release by the International Rice Research Institute of IR8, the first of the so-called high-yielding varieties (HYVs). Other changes which favored adoption of HYV were the low price for fertilizer and strong government support through Masagana 99. But the expansion of irrigation in the Philippines and elsewhere in Asia was the *cine qua non* of the green revolution. The investment by the United States, the World Bank, and others in the development of Asian agriculture reflected concerns of the developed world about a growing food shortage and the threat of Communism-cold war politics.

The National Irrigation Administration (NIA). In the Philippines, Republic Act 3601 entitled "An Act Creating the National Irrigation Administration" was signed into law in 1963 (NIA, 1990). There was a certain urgency in the face of rising rice imports. In 1965, Ferdinand Marcos was elected President and shortly thereafter Marcos appointed Alfred Junio as NIA's first Administrator, a position he would hold from 1966 to 1980. Throughout this period, NIA received strong support from the Marcos Administration.

There were two challenges confronting NIA: (i) guiding the financing and construction of large multi-purpose dams, and (ii) strengthening the role of the irrigation associations (IAs) in operation and maintenance of the irrigation systems.

Large dam construction. As documented later in this paper, with lending from the World Bank, Asian Development Bank, and bilateral sources especially Japan, investments for the construction of new systems rose sharply in the 1970s and 80s. Problems were encountered in project planning and design and maintenance and by 2010 the main focus was on rehabilitation.

Addressing the O&M problem. Early on in the 1970s, NIA designed and tested a program for participatory irrigation management (PIM) or irrigation management transfer (IMT). The objective was to transfer responsibility for O&M to the irrigation associations. This worked well with the communals but encountered problems and conflict of interest among the stakeholders in the national irrigation systems (NIS). For its efforts, NIA gained an international reputation. (Korten & Siy, 1989). This has been called the "golden age" of NIA. Visitors came from abroad to see the changes first hand. IMT was adopted in many locations in Asia.

A decade later, Asian Development Bank funded a study undertaken by the International Water Management Institute (Mukherji et al., 2009). Not surprisingly, this study provided mixed results. It has proved difficult to align the interests of stakeholders: policymakers and the general public, the donors, irrigation bureaucracy and its employees, and irrigation associations and farmer users.

Year 1985 to 2000

Groundwater revolution. The groundwater revolution, the rapid adoption, and diffusion of low-lift pumps in Asia began in the late 1980s. Initially, the majority of pumps were manufactured and exported from a small city in southern China (Huang, Rozelle, & Hu, 2007). Here once again problems arose. In this case, over time in many locations, farmers have depleted the aquifers. India, where pump irrigation exceeds canal irrigation, is a case in point. Farmers were not charged for electricity (Shah, 2009). In the Philippines, the development of shallow tube-well (STW) irrigation was private-sector led (David, 2003).

The NIA under pressure. Meanwhile, indications of decreasing efficiency in the planning and implementation of gravity irrigation projects were bringing NIA under pressure. With the end of the Marcos regime in 1986, NIA had to operate in a very politicized climate. NIA's power and control eroded (Panella, 2004). NIA was encouraged by the World Bank to scale back its ambitions. However, rice self-sufficiency continued (and continues) to be a paramount national objective.

Year 2000 to Present

Climate change. Since the turn of the century, there has been a growing concern about climate change. In agriculture, this has led globally to the development of "climate smart farming." This involves recommended adoption of cropping and water management practices that would mitigate the effects of climate change.

The Philippines is currently finalizing its climate change adoption plans as the country develops its strategies to address climate change in line with the Paris accord. Fortunately, practices that mitigate the effect of climate change and of carbon emissions in agriculture go hand in hand.

The growing demand for water in the Philippines for non-agricultural purposes. The continuing rapid population growth is increasing the demand for urban water and hydropower. The time may come when the Philippines gives up the drive for rice self-sufficiency and let countries like Vietnam, with plenty of water, grow the rice and export to the Philippines.

Trends in Public Sector Investment in Irrigation

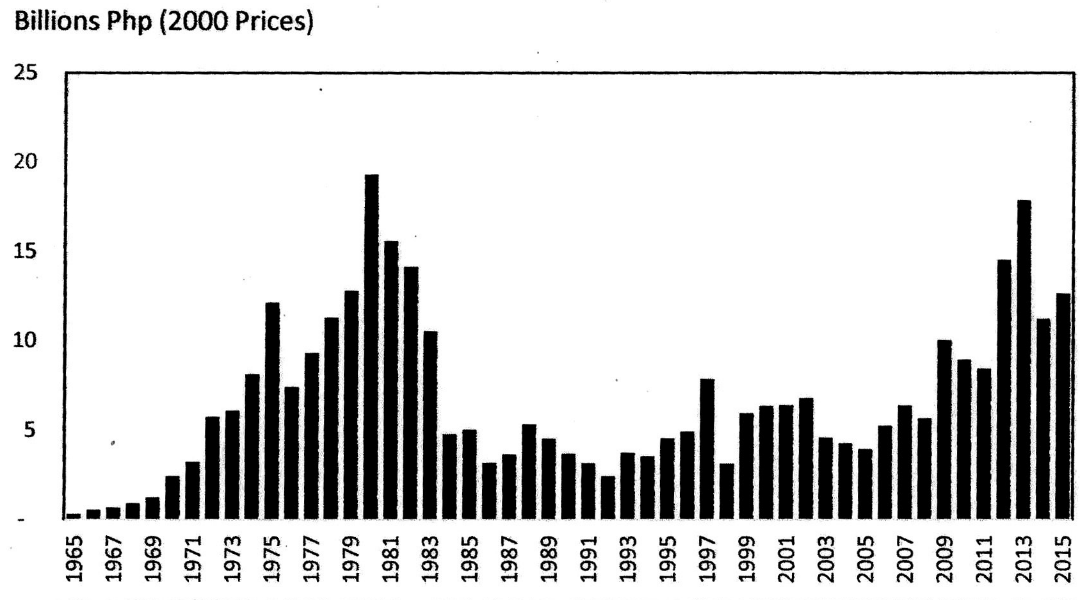
As noted in Figure 1, public sector investment in irrigation really began in the 1970s with the so-called green revolution. In fact, the public investment in irrigation in the Philippines and elsewhere can be argued as the *sina qua non* of the green revolution.

In the Philippines, the NIA was established in 1964 with the strong support of the Marcos Administration (rice, roads, and reelection). The Angat and the Pantabangan are the firsts of the multipurpose (irrigation, power, flood control) storage dams that were completed in the 1970s. NIS also manages run-of-the-river and pump irrigation.

Irrigation continues to be the largest public agricultural expense in the Philippines. In the 1970s and 1980s, public expenditures on irrigation represented about 45% of all public agricultural spending and 12% of all spending on infrastructure development (David & Inocencio, 2012).

Since the late-1980s, the relative importance of irrigation in public agricultural spending has declined by more than half, while its share of total spending on infrastructure has fallen to about 6%. In recent years, irrigation's share of public agricultural spending has increased to nearly 30%, and to about 10% of total spending on infrastructure.

The relative importance of irrigation as a policy instrument is even higher within the rice sector because publicly supported irrigation is primarily for



Source: Inocencio (in press). National Irrigation Administration (2016a).

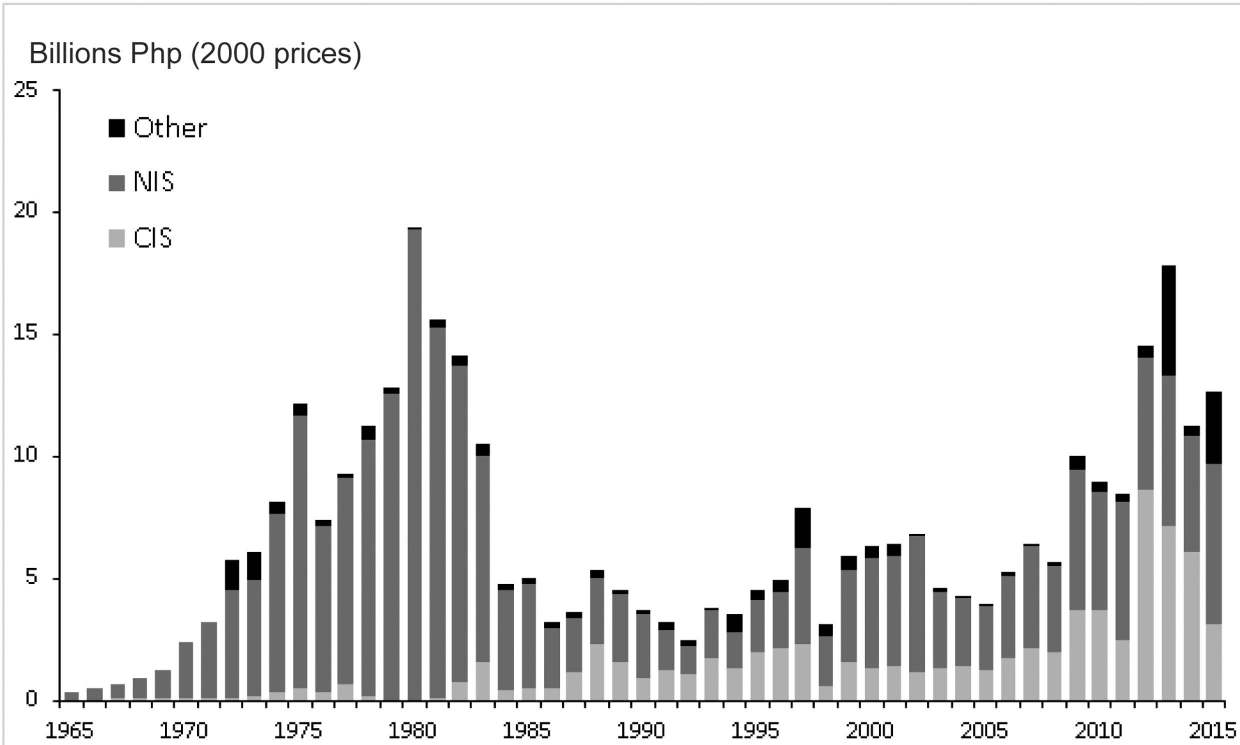
Figure 1. Trends in public investments in irrigation in real terms, 1965-2015.

surface gravity systems suited for rice cultivation, and the rice sector accounts for at least two-thirds of public agricultural expenditures. In 2015, total public expenditures for irrigation reached Php22 billion, 90% of which was allocated to capital investments and the remainder to corporate expenditures (such as staffing and other operating and maintenance costs). From 1976 to 2015, capital investments averaged 85% of total public expenditures for irrigation.

Over the past five decades, public capital investments in irrigation have fluctuated significantly, rising in the 1970s, declining drastically in 1983, and recovering to some extent in the early 1990s (Figure 1). The sharp increase in world rice prices in the 1970s (Dawe, 2010) together with the introduction of modern rice varieties suited to irrigated conditions, raised the marginal rates of returns to irrigation investments.

Public spending on irrigation declined as world commodity prices declined, yields of modern rice varieties leveled off, and the cost of irrigation expansion increased. Investments have risen again since 2008, likely in response to increased world rice prices, and this trend has continued with the present administration's food self-sufficiency program. More systematic analyses indicate that public investment levels respond to short-term changes in world rice prices because these changes affect the marginal rate of return to irrigation investment and the adoption of rice self-sufficiency rather than a consideration of the long-term costs and benefits (Hayami & Kikuchi, 1978; Azarcon & Barker, 1992; Kikuchi, Maruyama, & Hayami, 2003).

Until the early 1980s, about 95% of public expenditures on irrigation were allocated to NIS (Figure 2). Communal irrigation systems' (CIS) share began to rise by the mid-1980s as donor agencies focused on poverty reduction, and the government embarked on the Comprehensive Agrarian Reform Program (CARP) in 1988. As a result, CIS's share of total irrigation investments rose from an average of less than 5% in the 1970s to more than 40% in early 1990s. Foreign-assisted communal projects were typically part of the integrated area development projects (for example, Palawan Integrated Development Projects and the Southern Philippines Irrigation Sector Project) and agrarian reform-related projects. Local funding for communal projects had been mostly sourced from the Agrarian Reform Funds. During the late-1990s, NIS's share of irrigation investments once again increased—despite the passage of the Agriculture and Fisheries Modernization Act in 1997, which directed increased public support for small-scale irrigation systems and



Sources: Inocencio, (in press), National Irrigation Administration (2016a).

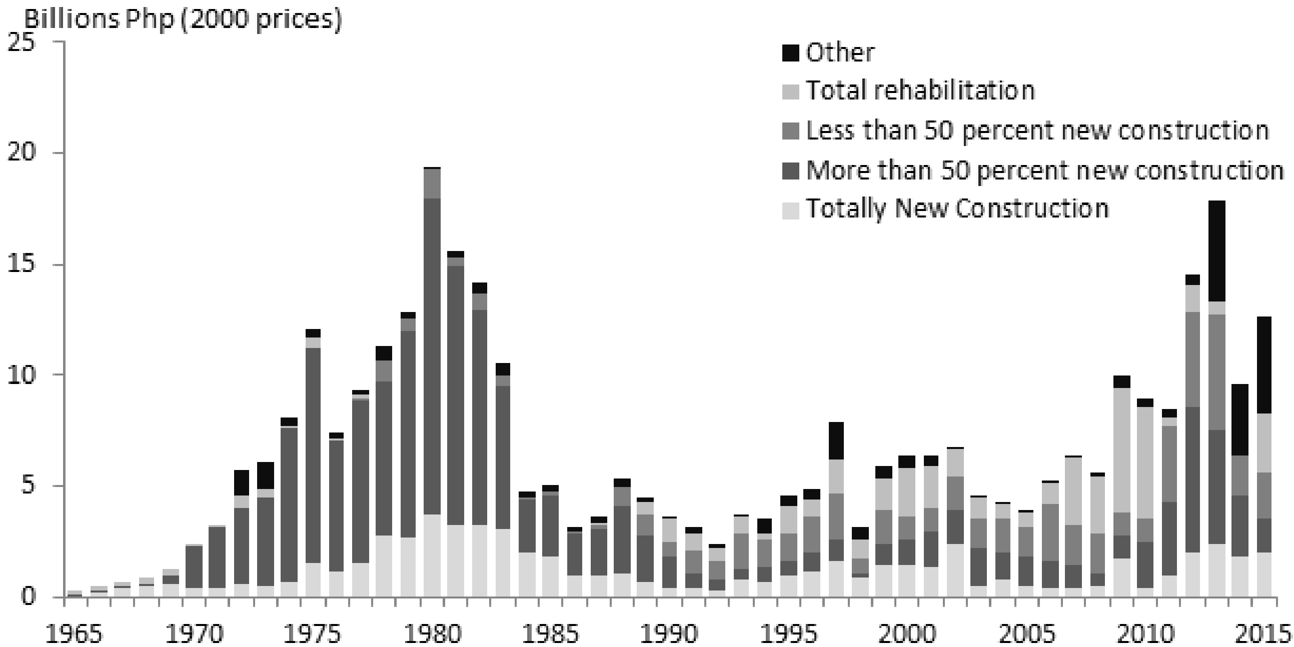
Figure 2. Trends in irrigation investments by type of system, 1965–2015.

groundwater resources development—but in more recent years the amount and share of investment in CIS have again expanded substantially.

With the passage of the Climate Change Act of 2009 (Republic Act 9729), climate change was mainstreamed in policy formulation. In response, the Department of Agriculture instituted the process of integrating climate change into its programs to protect and optimize agricultural and fishery production. This consideration could potentially increase investments in specific types of projects, although current on average, public investment in agricultural water during 1965–2015 was largely spent on new construction or the rehabilitation of irrigation systems (Figure 3).

The distribution of agricultural water projects according to purpose is indicative of the nature of these investments and their changing patterns over time. Investment projects are classified as (1) new construction only; (2) more than 50% new construction, with some rehabilitation and restoration; (3) more than 50% rehabilitation and restoration, with some new construction; (4) rehabilitation and restoration only; and (5) "Other," for projects that cannot be classified as either new or rehabilitation works (for example, the World Bank–funded Watershed and Erosion Management Project in the early 1980s).

From 1965 to 2015, an average of 19% of irrigation investments were allocated to totally new construction, including medium and large pump systems that draw water from major rivers, such as the Abra River in Abra, Libmanan Cabusao in Bicol, and Lower Agusan in Mindanao (Inocencio, in press). About two-thirds of expenditures funded irrigation projects that combined the construction of a newly irrigated area with the rehabilitation of existing gravity-based NIS or CIS. Most of these irrigation projects integrated, expanded, and modernized several smaller irrigation systems by constructing large reservoirs upstream (such as in the two largest systems, Upper Pampanga River Integrated Irrigation System [UPRIIS] and MRIIS) or strengthened headworks further upstream (such as in the Ilocos Norte Integrated Project or the Upper Chico Irrigation Project). More recent projects established a regulating pond for the Agno River water from the



Sources: Inocencio (in press), National Irrigation Administration (2016a).
Note: "Other" increased starting 2013 due to the provisions for non-component of San Roque Multi-purpose project paid to NPC-PSALM.

Figure 3. Trends in irrigation investments by use, 1965–2015.

hydropower plants in Ambuklao and Binga Dams to increase water supply for an integrated and rehabilitated national system in Pangasinan. Only about 12% of irrigation investments were for rehabilitation and restoration purposes. The share of budgets for totally or predominantly new construction projects declined from the 1990s. Conversely, the share of rehabilitation only projects rose as high as 30% during 2009–2010. These patterns are consistent with the expectation that, as the more suitable sites for irrigation are developed over time, the benefit–cost ratios for rehabilitation projects become more favorable compared with the construction of a newly irrigated area (Kikuchi et al., 2003; Inocencio et al., 2007).

Overall, a significant share of expenditures on NIS during 1965–2015 was directed toward projects based on new or predominantly new construction—57% and 24%, respectively, for a total of 81%—compared with entirely or predominantly rehabilitated areas—10% each, for a total of 18% (Table 1). Similarly, more of the expenditures on CIS projects focused on new or predominantly new construction (66%). Consistent with the overall trends, projects involving foreign-assisted funding focused increasingly on rehabilitation projects over time, both for NIS and CIS. About two-thirds of all expenditures involving foreign-assistance were allocated to projects predominantly focusing on the newly irrigated area, whereas projects for newly irrigated areas only contributed about 21%. Although the World Bank, Asian Development Bank, and (in more recent years) Japan have funded mainly rehabilitation projects, the share of projects with more than 50% rehabilitation, combined with new construction, was relatively small, at about 10%, but increased over time.

Locally funded projects were split up between new or predominantly new construction projects and projects predominantly or entirely involving rehabilitation (40% and 36% of the total during 1965–2015, respectively). The share of the latter rose from about 50% in the 1980s to about 70% or more in the 1990s and 2000s. Much of this funding is appropriated in lump sums for repairs, restoration, rehabilitation, and new construction of NIS, CIS, or pump systems, either directly to the NIA or indirectly through other government agencies (such as the Department of Agrarian Reform, Department of Public Works and Highways, or local government agencies).

Trends in Private Sector Investments

Table 1. *Distribution of Irrigation Investments by Purpose, Type, and Funding Source, 1965–2015*

	1965 –2015	**1965 –1969**	**1970 –1979**	**1980 –1989**	**1990 –1999**	2000 –2009	2010 –2015
Irrigation system	**Share of total investment (%)**						
National irrigation systems							
New construction only	24	50	17	28	35	22	14
More than 50% new construction, combined with rehabilitation and restoration only	57	14	78	64	21	23	39
More than 50% rehabilitation and restoration, combined with new construction	8	0	2	6	12	25	18
Rehabilitation and restoration only	10	36	3	1	32	30	30
Subtotal	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Communal irrigation systems							
New construction only	16	41	21	1	5	8	26
More than 50% new construction, combined with rehabilitation and restoration	50	59	79	92	17	19	48
More than 50% rehabilitation and restoration, combined with new construction	28	0	0	7	65	29	11
Rehabilitation and restoration only	7	0	0	0	13	44	16
Subtotal	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Foreign-assisted projects							
New construction only	21	51	11	24	33	29	9
More than 50% new construction, combined with rehabilitation and restoration	65	49	85	69	28	35	50
More than 50% rehabilitation and restoration, combined with new construction	9	0	2	2	20	32	37
Rehabilitation and restoration only	3	0	1	1	17	5	3
Other	2	0	2	4	3	0	0
Subtotal	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Locally funded projects							
New construction only	19	49	41	25	5	8	14
More than 50% rehabilitation and restoration, combined with new construction	21	11	16	26	4	9	24
Less than 50% new construction, combined with rehabilitation and restoration	23	0	5	46	40	20	24
Rehabilitation and restoration only	13	40	11	3	28	57	10
Other	25	0	27	0	23	7	27
Subtotal	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Combined total of all projects							
New construction only	19	49	16	24	20	17	13
More than 50% new construction, combined with rehabilitation and restoration	45	18	74	65	17	21	30
More than 50% rehabilitation and restoration, combined with new construction	15	0	2	6	29	25	25
Rehabilitation and restoration only	12	33	2	1	22	33	14
Other	8	0	6	3	12	4	19
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sources: Inocencio (in press), National Irrigation Administration (2016a).

in Irrigation

The irrigated area continued to expand with the introduction in the late 1980s, by the Chinese, of low-cost low-lift pumps—the so-called groundwater revolution. The use of pumps spread rapidly throughout Asia (Barker, 2002; Shah et al., 2007; Giordano & Villholth, 2007). But unfortunately for the Philippines, the data on private sector pumps is difficult to establish from the official statistics with National Statistics Office (NSO) and NIA data radically different (Inocencio, 2016). Figure 4 indicates that individual systems, which include the use of pumps or shallow tube wells among other types, have been rapidly growing. The pumps may also be low-lift and drawing from surface water or irrigation canals.

Nonetheless, the data from NIA (Table 2) indicate that most of the private systems (likely pumps and STWs) are in Luzon and that pumps account for a little over 10% of the irrigated area.

However, Figure 5 for the UPRIIS system in Central Luzon illustrates the impact that first the green revolution (Pantabangan Dam) and then the groundwater revolution (dry season pumps) has had on the area irrigated.

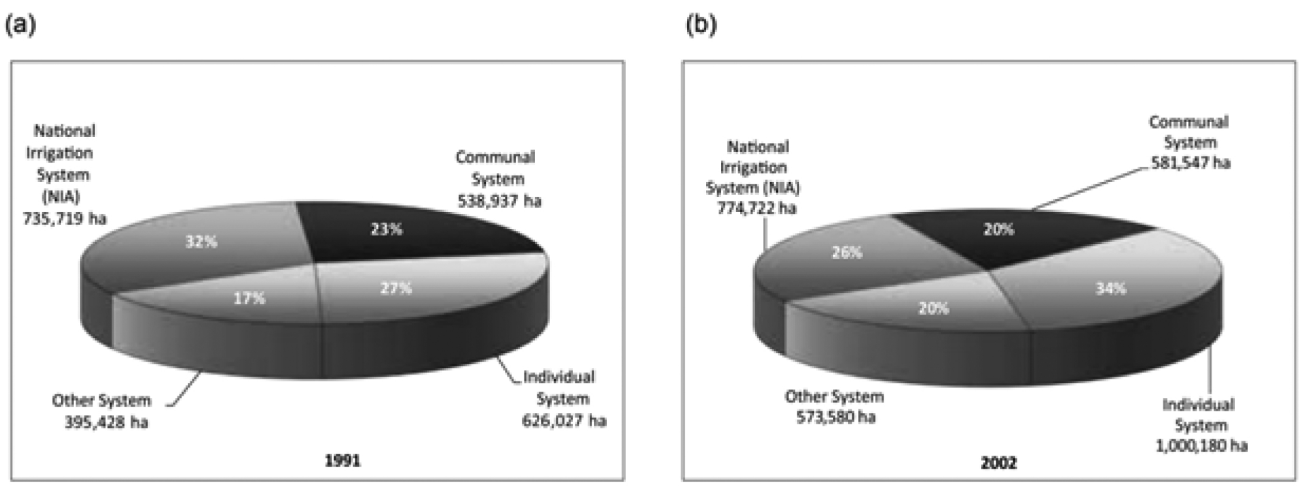
The advantage of pumps is that it provides water on demand. For example, NIA water releases are not always timed to water needs, but pumps can provide water at flowering, which is essential for high yield. Pumps have also increased the area irrigated in the dry season.

The success of the green and groundwater revolutions has permitted a shift of political concern from food production to the needs of the industrial and urban sectors, reducing attention to the problems of the agricultural sector at the same time that of **competition for water** was increasing.

Issues in Project Planning and Design, Operation and Management (O&M), and Rehabilitation

At the outset it is important to recognize that the policies/politics and subsequent problems of the above three issues are totally interrelated although we treat them one-at-a-time.

Project Planning and design



Source: Inocencio and Barker (2006).
Notes: The NSO (now PSA) Census of Agriculture defines irrigation as the practice of artificially providing land with water to increase its agricultural productivity and irrigated farms are those lands provided with artificial irrigation system. Four types of systems are identified: (1) national irrigation system – a government owned irrigation system built and constructed to provide continuous supply of water for agricultural purposes to farmers for a fee; (2) communal – an irrigation system owned by the community, association farmers' cooperative, etc.; (3) individual – an irrigation means provided personally by the operator for his holding/farm's irrigation needs; this could be rented, borrowed, or owned by any member of the household; (4) other systems – include water fetching,

Figure 4. Distribution of irrigated parcel area by type of main irrigation systems, Philippines, 1991 and 2002.

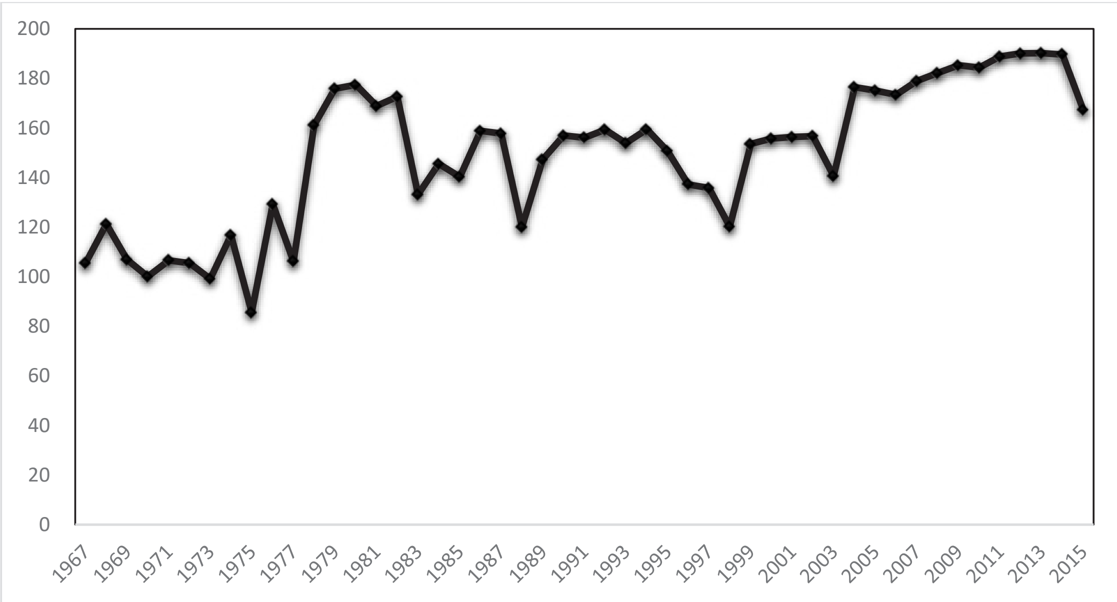
Table 2. *"Firmed-up" Irrigation Service Area by Region, as of 2015*

Region	Total	National irrigation systems	Communal irrigation systems	Private irrigation systems	Other gov't-assisted service areas
	Area as a share of the national total (%)				
CAR	5	2	8	13	2
Region 1 (Ilocos Region)	10	6	9	11	29
Region 2 (Cagayan Valley)	16	20	9	24	12
Region 3 (Central Luzon)	17	26	11	5	11
Region 4a (CALABARZON)	3	3	3	3	1
Region 4b (MIMAROPA)	5	3	6	8	7
Region 5 (Bicol Region)	8	3	12	13	9
Total for Luzon	*64*	*63*	*58*	*78*	*73*
Region 6 (Western Visayas)	7	6	6	8	9
Region 7 (Central Visayas)	3	2	4	2	1
Region 8 (Eastern Visayas)	4	3	6	3	2
Total for Visayas	*13*	*11*	*16*	*14*	*11*
Region 9 (Zamboanga Peninsula)	3	2	4	1	2
Region 10 (Northern Mindanao)	**4**	3	4	3	2
Region 11 (Davao Region)	4	5	4	1	2
Region 12 (SOCCSKSARGEN)	7	8	6	2	6
Region 13 (Caraga)	4	4	4	2	4
ARMM	3	3	3	0	0
Total for Mindanao	*23*	*26*	*26*	*9*	*16*
Total area of the Philippines (ha)	**1,731,128**	**754,666**	**615,797**	**187,767**	**172,899**

Source: National Irrigation Administration (2016c).

Moya (2013) carried out case studies on the causes of the poor performance of NIS. Observations corroborated earlier findings that many of these concerns can be traced to flawed economic and technical assumptions during the planning and design phase, and problems during the construction phase. Gaps have been found between design assumptions and operational realities causing systems to underperform. For instance, estimations of field water requirements and water losses throughout the system were grossly underestimated. The 1–2mm per day seepage and percolation rate assumed in conventional design procedures was 8 to 40 times lower than those measured in the field. These faulty assumptions resulted in the overestimation of the area able to be irrigated within a system. Complicating such estimations were reported degradations of watersheds affecting both the quantity and quality of available water. Watershed changes need to be taken into account to improve the planning and design of agricultural water projects, which in turn must include water reliability analyses. Aside from rainfall intensity, river water discharges that can be diverted for irrigation depend on a number of interacting factors, such as land cover and use within the watershed.

The case studies indicate other design concerns that have not been addressed appropriately through O&M practices. For example, intakes in rivers with steep side slopes and sediment entrainment usually become clogged and require frequent desilting, which has not been factored into O&M programs. This situation is made worse when natural disasters or higher rainfall intensities occur. Turnouts and other water-distribution facilities have been poorly designed, misaligned, and constructed inappropriately to function within a range of canal water elevations. In addition, building dams



Irrigation Development: UPRIIS (1975), Low-lift Pumps (1990s) → Cropping Intensity ↑

Sources: Inocencio, et al. (2016), National Irrigation Administration (2016b).
Note: Cropping intensity is calculated as actual wet and dry irrigated areas divided by service area or firmed up service area.

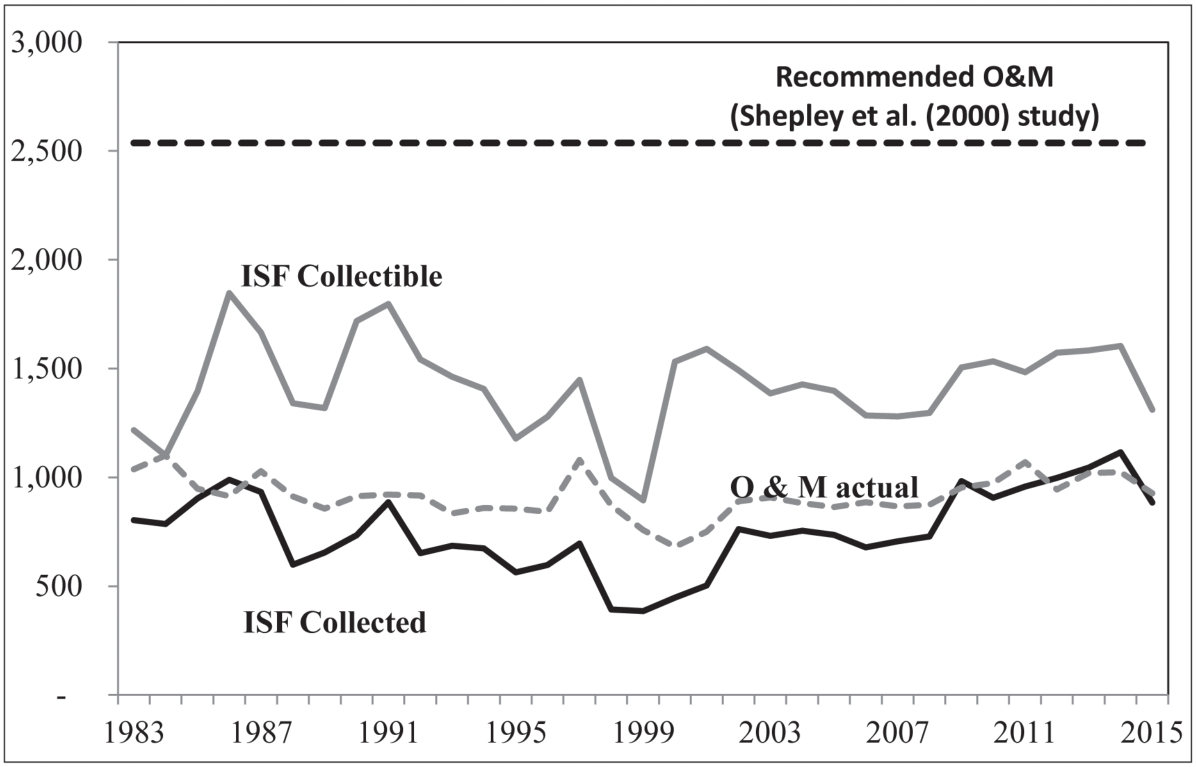
Figure 5. UPRIIS Cropping Intensity, 1967-2015.

at the foot of hillside slopes presents a high risk of structures being filled in or washed out during floods. In a number of cases, the river course has shifted away from the point of abstraction and diversion of irrigation systems. Changes in river courses due to sedimentation, in turn, result in numerous O&M issues in run-of-the-river diversion and surface pump systems. In extreme cases, headworks have been washed out or completely covered by sediment due to strong river flows. Resources need to be allocated each year or during planting season to enable water to be redirected or diverted into the irrigation system service area. Another factor is the reality that the conditions of catchments are insufficiently monitored to enable changes in erosion, transport, and sedimentation to be predicted. Such changes can decrease water yields.

Readily available technologies and tools to systematically address the above concerns—such as modeling, geographic information systems, and remote image sensing—are not being sufficiently utilized to facilitate more accurate calculations of available water for irrigation. While relatively recent systems may have access to such tools, they are not available to smaller and older systems. It seems logical to compare the costs of building river training structures with the costs of frequently rehabilitating washed-out or filled-in dams. Design engineers tend to use tried-and-tested design approaches but ignore potentially valuable lessons from past projects. As a result, problems persist in irrigation system performance. This situation is further exacerbated by lack of input by operations units in the design of irrigation systems.

Many design parameters stipulated in manuals produced by design engineers do not reflect field realities, complicating the role of operations staff, who take over once construction is completed.

Tabios and David (2014) examined discrepancies between the estimated and actual irrigated areas of NIS. The actual irrigated area of Angat-Maasim River Irrigation System (AMRIS) is only 75% of the estimated design area during the dry season and only 55% of the estimated area during the wet season. These discrepancies occur for three reasons: (1) about 3,500 ha of the total area have elevations of at least 19 meters and hence cannot be irrigated with water from



Sources: NIA(2016b) ; Shepley, et al. 2000.

Figure 6. Trends in the actual cost of O&M of SA compared with recommended levels and to ISF collections of NISs at 2000 prices.

the Bustos Dam, which has a maximum crest elevation of 18.5 meters; (2) in the past few years, built-up or urbanized areas total about 4,500 ha, so about 8,000 ha of the original AMRIS design area cannot be irrigated; and (3) for the wet season, an additional 5,500 ha of the area with elevation below seven meters would become flooded, reducing the actual wet irrigated area to a little over half the estimated design area. These case studies indicate that even the more recent agricultural water projects are flawed by numerous planning, design, and construction issues that climate change will further complicate.

Operation and Maintenance

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

NIA was divided into two units: "construction" and "operation and maintenance" (O&M). With the initiation of the Angat River multi-purpose project and the UPRIIS in the 1970s, the budget for construction grew rapidly (Inocencio & Barker, 2006). This was aided by loans from the Asian Development Bank and other foreign lenders.

According to Shepley, Buenaventura, and Roca (2000), the recommended per ha cost of O&M to cover the average direct costs of water scheduling and gate operations, canal-cleaning labor, gate repairs/greasing and locks, use of hand-held radios, and equipment rental is at least double the current fees charged in river diversion and reservoir systems. Actual spending on O&M at the field level is significantly less than the collectible service fees in the wet and dry seasons because the collection rate has averaged only about 50% in the 1980s and 1990s, rising to slightly higher than 60% in the decade preceding 2012 (Figure 6). The poor collection efficiency can be attributed to a combination of many factors which include: (a) difficulty to collect from farmers especially those who are relatively well off and can easily evade collectors or those who were unhappy with the service; (b) absence of a penalty system that can be enforced—this is because those who do not pay cannot be excluded from the service given the design of most irrigation systems (except for pump systems); (c) some farmers refused to be part of the IA and pay the service fees despite location of farms inside the irrigation system; and (d) poor management systems. Furthermore, Shepley et al. (2000) found that about 40% of the workers' time is devoted to service fee collection, rather than to O&M. Real O&M expenditures and O&M per ha have declined in several regions and will result in the further deterioration and poor performance of irrigation systems (Inocencio, in press). The poor performance of many of these systems may be reflected in low regional cropping intensities and (wet and dry season) irrigation intensities (Inocencio, in press).

There were concerns that existing systems and resources for irrigation were being poorly managed. With irrigation fee collection over 60%, O&M still largely depended on subsidies. To address these issues, NIA began testing a plan for *participatory irrigation management* (PIM) or *irrigation management transfer* (IMT). That is to say, turning over the responsibility for maintenance at the lower turn-out level to users.

Presidential Decree 552 (1974) gave NIA the responsibility for supporting CIS. A Communal Irrigation Committee (CIC) was formed to assist NIA in implementing the Participatory Irrigation Management Program. The committee included a wide range of disciplines from academia and elsewhere and received support from the Ford Foundation.

It soon became evident that what worked with the communal systems was not going to work with the more complex relationship among stakeholders in the national systems. Shifting responsibility from NIA to the Irrigation Associations (IAs) would result in a loss of jobs from those in O&M. The tail-enders in the IAs often did not realize they were members of the association and irrigation fee collection remained at over 60%.

These factors notwithstanding, lenders like the World Bank have continued to make participatory irrigation management a condition for loans. But neither side presses the issue which is accepted in the breach. The attempt to develop a successful O&M program continues. That is to say, one that establishes an equitable role of the government in providing subsidies, NIA in managing the main laterals, and the irrigation associations/water users in providing fees.

The Government is currently testing a new plan for O&M. NIA Memorandum Circular "Guidelines on Free Irrigation Services" is being finalized although the implementation started as early as 2017. This puts responsibility for O&M performance at turn-outs in the hands of the IA heads.

Rehabilitation

Both problems in construction and operation and maintenance have led to early rehabilitation. For example, the five medium-sized NIS first built with Asian Development Bank (ADB) funding in Mindanao in the 1970s up until the early 1980s (Banga, Marbel, Saug, Simulao, and Pulangui) underwent major rehabilitation in the 1990s—only 10 to 15 years after their construction). Major rehabilitation of UPRIIS—the largest NIS, supposedly with a 50-year lifespan—was undertaken only 25 years after its completion as part of the Casecnan Irrigation Component Project, funded by a Japanese loan.

These observations are consistent with estimates of the rehabilitation cycle based on information for 141 systems (Table 2). Whereas NIS built prior to 1965 required rehabilitation after about 30 years, the cycle for NIS built between 1965 and 1980 was only 18 years, and for more recent projects, the average is only nine years, which is far shorter than the average across all systems of 20 years. Based on a sample of 40 NIS, Shepley et al. (2000) found the average interval from the start of operation to the first major rehabilitation to be 19 years, with a standard deviation of 14 years. This can be compared with an international norm of 25 to 30 years.

Paths to Improve Water Management and Increase Water Productivity

Often in the reports detailing plans and targets for rice self-sufficiency, there is no mention of water. Yet development and management of water resources continue to be the *cine qua non* from the past and present to the future of Philippine agriculture.

Today's management takes place in an environment of water scarcity. Responses to water scarcity, that is to say increasing water productivity, are extremely

Table 2. *Average Number of Years Before First Major Rehabilitation*

Vintage	Average Number of Years before Rehabilitation	No. of NISs with Recorded Rehabilitation
All systems	20	141
Before 1965	32	51
1965–1980	18	41
1981–1995	9	49
1996–2008	-	-

Source: Inocencio, David, and Briones (2013).

varied but can be classified into four major headings (Barker & Molle, 2004): (i) conservation or real water saving, (ii) supply augmentation: resistance to abiotic stresses—salinity, drought, flood; (iii) reallocation to higher valued uses; and (iv) crop diversification.

Water saving activities can take place at local or farm level or implemented primarily by government agencies or donor-assisted projects. It should also be noted that appropriate solutions are very site-specific, depending on both the physical and socio-economic environment the following two examples will illustrate the point.

Alternate Wetting and Drying

Alternate wetting and drying or keeping the paddy saturated but not flooded can save as much as 40% of the water at the farm level. But the farmer must have access to water at the critical stage of rice flowering. Surface irrigation systems cannot deliver water on demand. The farm must have a pump and/or a farm pond for water storage. The reduction of the water requirement may also affect his neighbor, so a joint effort is desirable.

Canal Lining

Canal lining is extremely popular among both lending agencies and recipient governments. They provide lenders with an opportunity to meet monetary disbursement targets and irrigation agencies with the opportunity for "rent seeking" or *skimming profits* (Repetto, 1986). But more importantly, unlined canals in many areas serve to recharge the groundwater. Thus, there may have been no real water savings.

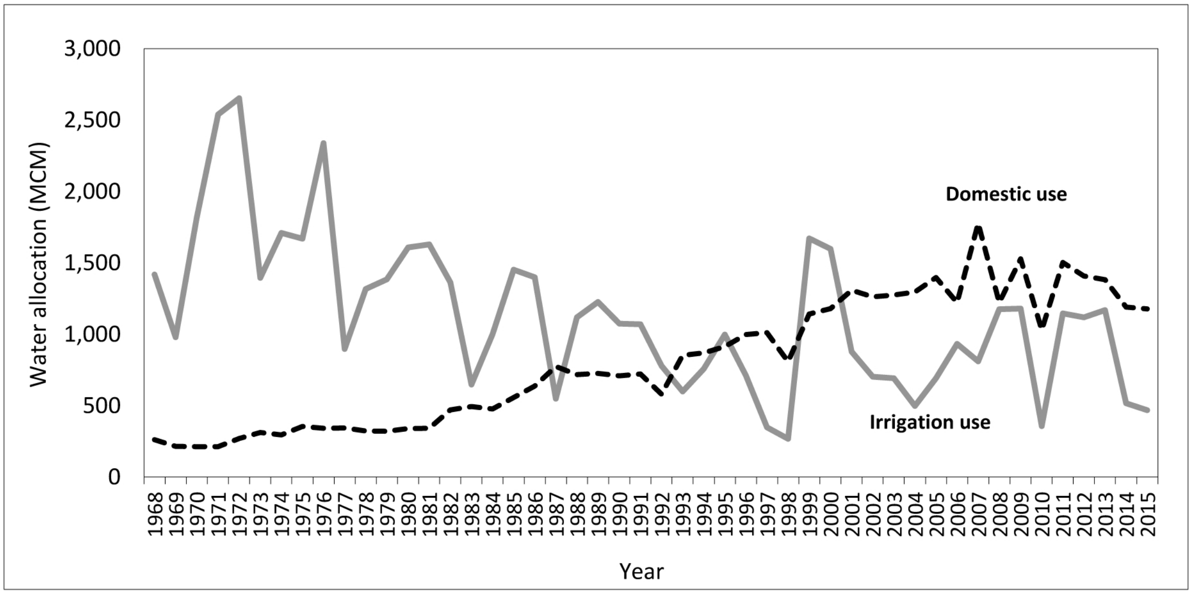
Reallocating Water From Agriculture to Higher Value Uses

Figure 6 shows the reallocation of water from Angat Dam to Manila, that is, from agriculture to higher valued urban usage. The Angat reservoir provides water for irrigation, domestic use in Metro Manila, hydropower generation, and flood control. Angat water is being allocated over time between domestic water users and rice and vegetable farmers in Bulacan. Metro Manila is provided with a steadily increasing supply while water for Bulacan farmers has been variable. In 1997–98, the NIA had to suspend the operation of the Angat-Maasim River Irrigation System for the entire dry season in favor of the Metropolitan Waterworks and Sewerage System (MWSS) domestic water users. Aside from this, there are no others cited in literature except for a few which are not intersectoral and are between agriculture users.

The demand for water for non-agricultural purposes will continue to grow. There are situations where the reduction in surface water for agriculture will force farmers to adopt low-lift pumps or develop farm ponds. For example, this occurred in the case of the eruption of Mt. Pinatubo in 1991 which destroyed the storage dams and forced Tarlac farmers to adopt low lift pumps and alternate wetting and drying AWD not to save water but the cost of fuel.

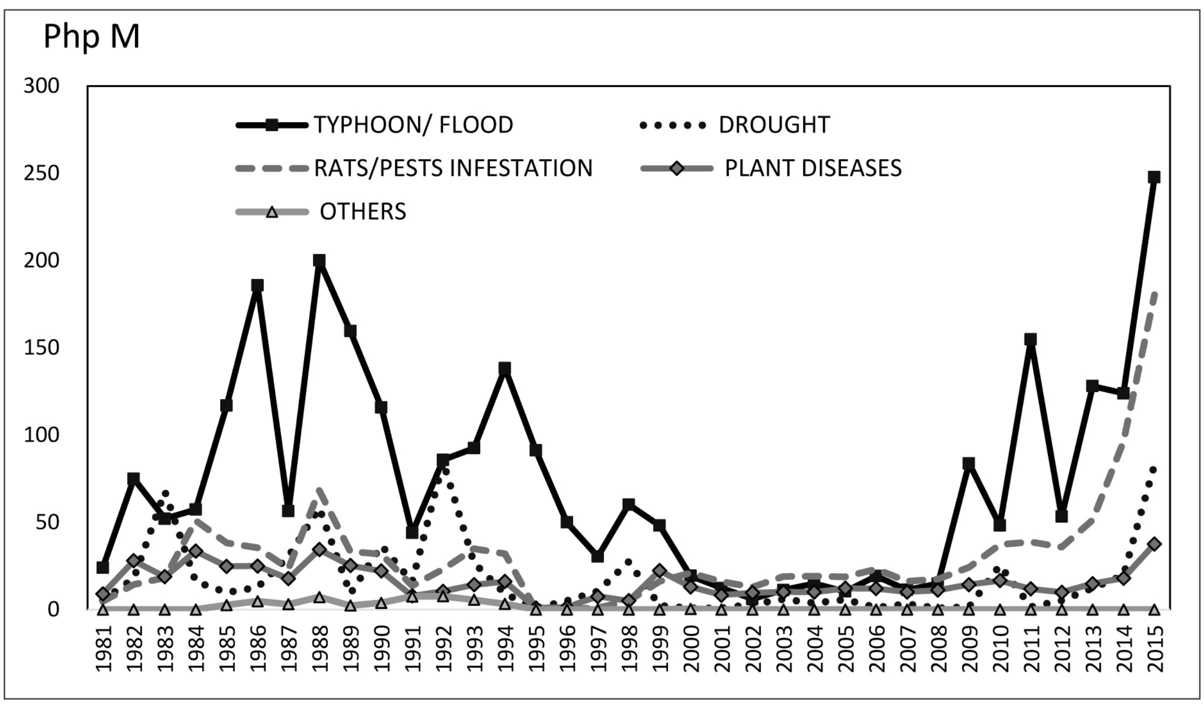
Crop Diversification (Reallocating Water Within Agriculture)

It goes without saying that rice self-sufficiency has remained an elusive target of Philippine government administrations. But the discussion has broadened to include food security, and competitiveness of Philippine rice in the global market (Bordey, Moya,



Source: National Water Resources Board (2016) for basic data.

Figure 7. Angat water consumption between the Metropolitan Waterworks and Sewerage System and the National Irrigation Administration, 1968–2015.



Source: Philippine Crop Insurance Corporation (2016) for basic data.

Figure 8. Real production loss claims for palay due to various factors (2000 prices), 1981-2015.

Beltran, Launio, & Dawe, 2016). Crop diversification or rice-based cropping systems is perhaps more widely practiced than most people realize. Philrice has an active research program in crop diversification. The typical pattern in rice-based systems is to grow rice in the wet season and another crop in the dry season.

Climate and Climate Change

The Philippines as a country has been marked by extreme weathers. The farming community knows this well. The key concern is typhoon damage to crops due to strong winds and flooding (Figure 7) which had been consistent except in early to mid-2000.

Has climate change resulted in the frequency and impact of typhoons? Table 3 shows significant damages in irrigation and other infrastructure. Five of the 10 deadliest typhoons occurred since 2006. Furthermore, as the ocean surface temperature increases over time, the additional heat from the ocean and the air can lead to stronger and more frequent storms. Notably, damages from droughts do not appear to be as big as those from typhoons and floods. This situation could be possibly due to the ability of farmers to cope better to the first than the later.

As noted above, the passage of the Climate Change Act of 2009 has mainstreamed climate change interventions in all relevant departments including the Department of Agriculture. However, it appears that most of the government funding is being spent on new construction and rehabilitation. A relatively small portion of the expenditure was being allocated to strengthen the irrigation associations, training NIA staff, and running agricultural extension activities.

Virtual Water

Over the last several decades the use of blue water (e.g. climate change) has received increasing attention in both research and policy concerns. But little attention has been paid *to* the quantification of *green water* in agricultural and industrial production and trade (Zimmer & Renault, 2003). If one country exports a water intensive product to another country (e.g. Thailand exports rice to the Philippines), it is said to export water in a virtual form. The term "virtual water" was coined by Allan (1988). As expected, cereals are the highest contributor to virtual water trade.

The Philippines, during the five-year period 1995--99 went from being a net exporter of virtual water to net importer (Hoekstra & Hung, 2002). Determining whether this was a result of climate factors, the growth in population, or some other cause such as rice self-sufficiency, has important policy implications for the country.

Conclusions

Managing water resources is highly complex and influenced by politics and policies, good and bad. What works in one location may not work in another. We noted at the outset that the Philippines faces a new situation with limited capacity to expand the irrigated area, lack of knowledge about groundwater aquifers, and potential negative impacts of climate .

Even with the new situation, the old problems seem to persist: problems in project planning and design and poor operation and maintenance lead to an early need for rehabilitation. This would seem to be due in part to poor management and to politics. For example, not since the mid-1980s has NIA had a director for more

Table 3. *Damage to Agriculture Infrastructure and Facilities Due to Typhoons, Drought and Floods (Php M)*

Year	Irrigation	Other Infrastructure and Facilities
2011	2,144	242
2012	1,736	83
2013	2,181	3,508
2014	162	436
2015	82	285
Total	6,305	4,553

Source: Field Programs Operational Planning Division (2016).

than a couple of years.

Despite these concerns, there are paths to increasing water productivity and improving water management, some of which are currently being pursued. However, given the uncertainties of climate, and potential impact of virtual water, it will take a good deal of skill, effective research, and policies to maintain a secure water situation. At the same time, with the uncertainty posed by climate change, it will be necessary to continue to rely on rice imports.

References

Allan, J. A. (1988). Virtual water: A strategic resource global solutions to regional deficits. *Groundwater, 36*(4), 545–546.

Azarcon, Y., & Barker, R. (1992). *Trends and determinants of irrigation investment in the Philippines* (Agricultural Policy Analysis Project, Phase II, Collaborative Research Report No. 321). Colombo, Sri Lanka: International Water Management Institute.

Barker, *R*., & *Molle, F*. (*2004)*. *Evolution of irrigation in South and Southeast Asia* (Comprehensive Assessment Research Report 5). Colombo, Sri Lanka: Comprehensive Assessment Secretariat, International Water Management Institute.

Barker, R. (2002). Recent developments in irrigation management in Asia and the Pacific. In *Organization change for participatory irrigation management: Report of the APO Seminar* (pp. 21–31). Tokyo, Japan: Asian Productivity Organization.

Bordey, F. H., Moya, P. F., Beltran, J. C., Launio, C. C., & Dawe, D. C. (2016). Can Philippine rice compete globally? In F. H. Bordey, P. F. Moya, J.C. Beltran, & D. C. Dawe (Eds.), *Competitiveness of Philippine rice in Asia* (pp. 141–151). Science City of Muñoz, Philippines: Philippine Rice Research Institute and Manila, Philippines: International Rice Research Institute.

Climate Change Act of 2009 (Republic Act 9729).

David C., & Inocencio, A. (2012). *Irrigation policy and performance indicators in the Philippines* (Final report under the Monitoring and Evaluation of Agricultural Policy Indicators Project). Makati City Philippines: Philippine Institute for Development Studies.

Dawe, D. (Ed). (2010). *The rice crisis: Markets, policies, and food security.* Rome: FAO.

David, W. P. (2003). *Averting the water crisis in agriculture: Policy and program framework for irrigation development in the Philippines*. Manila: University of the Philippines Press.

Field Programs Operational Planning Division. (2016). *Damage to agriculture infrastructure and facilities due to typhoons, drought & floods*. Quezon City: Department of Agriculture.

Giordano, M., & Villholth, K. (Eds). (2007). *The agricultural groundwater revolution: Opportunities and threats to development* (Comprehensive Assessment of Water Management in *Agriculture* Series 3). Wallingford, UK: CABI.

Hayami, Y., & Kikuchi, M. (1978). Investment inducement to public infrastructure irrigation in the Philippines. *Review of Economics and Statistics, 60*(1), 70–77.

Hoekstra, A. Y., & Hung, P. Q. (2002). *Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade* (Value of water Research report series No. 11). Netherlands: IHE Delft.

Huang, Q., Rozelle, S., & Hu, D. (2007). Pump-set clusters in China: Explaining the organization of the industry that revolutionized Asian agriculture. *Asia-Pacific Development Journal, 14*(2), 75–105.

Inocencio, A. (in press). Trends in agricultural water resources. In *The future of Philippine agriculture: Scenarios, policies, and investments.* Singapore: Climate Change Institute of Southeast Asian Studies Publishing.

Inocencio, A. B., Elazegui, D. D., Luyun, R. A., & Rola, A. C. (2018) Agricultural water management issues in the Philippines. In A. Rola, J. Pulhin, R. A. Hall (Eds.), *Water policy in the Philippines: Issues, Initiatives, and Prospects* (pp. 117-141). Cham, Switzerland: Springer International Publishing.

Inocencio, A. B. (2016). Water in agriculture: Key challenges and opportunities for the Philippines. In S. Banta (Ed.), *Water in agriculture: Status, challenges and opportunities* (Papers presented at The Asia Rice Foundation (ARF) Annual Rice Forum, 24 November 2015, DOST-PCAARRD, Los Baños, Laguna, Philippines; pp. 221-274 Laguna: Asia Rice Foundation.

Inocencio, A. B., Ureta, C., Baulita, Alex, Baulita, Arman, Clemente, R.S., Luyun, R. Jr., Elazegui, D.D. (2016). Technical and institutional evaluation of selected national and communal irrigation systems and characterization of irrigation sector governance structure. (Philippine Institute for Development Studies Discussion Paper no. 2016-12). Makati, Philippines: Philippine Institute for Development Studies.

Inocencio, A., David, C., & Briones, R. (2013). *A rapid appraisal of the irrigation program of the Philippine Government* (Final report). Makati, Philippines: Philippine Institute for Development Studies.

Inocencio, A. B., & *Barker*, R. (*2006)*. Water resources and irrigation development. In A. M. Balisacan, & L. S. Sebastian (Eds.), *Securing rice, reducing poverty: Challenges and policy directions* (pp. 71–105). Los Baños, Philippines: Southeast Asian Regional Center for

Graduate Study and Research in Agriculture (*SEARCA*).

Kikuchi, M., Maruyama, A. & Hayami, Y. (2003). Phases of irrigation development in Asian tropics: A case study of the Philippines and Sri Lanka. *Journal of Development Studies, 39*(5), 109–138.

Korten, F. F., & Siy, R. Yl, Jr. (Eds.). (1989). *Transforming a bureaucracy: The experience of the Philippine National Irrigation Administration.* West Hartford Connecticut: Kumirian Press.

Lewis, H. T. (1980). Irrigation societies in the northern Philippines. In E. W. Coward, Jr. (Ed.), *Irrigation and agricultural development in Asia: Perspectives from the Social Sciences* (pp. 153-171). Ithaca, New York: Cornell University Press.

Moya, T. (2013). *Analysis of technical assumptions and processes of evaluating feasibility of irrigation projects*. Makati City, Philippines: Philippine Institute for Development Studies.

Mukherji, A., Fuleti, B., Shah, T., Suhardiman, D., Giodano, M., & Weligamage, P. (2009). *Irrigation reform in Asia: A review of 108 cases of irrigation management transfer* (Final report submitted to the Asian Development Bank). Colombo: International Water Management Institute.

National Irrigation Administration. (2016a). NIA Yearend Report. Quezon City: NIA Office of the Corporate Planning Services.

National Irrigation Administration. (2016b). *National irrigation system performance (NISPER) data*. Quezon City: NIA Systems Management Division.

National Irrigation Administration. (2016c). *Irrigation development by region by type of system*. Quezon City: NIA Office of the Corporate Planning Services.

National Irrigation Administration. (1990). *A comprehensive history of irrigation in the Philippines*. Quezon City: NIA.

National Water Resources Board. (2016). *Angat water consumption between the Metropolitan Waterworks and Sewerage System and the National Irrigation Administration, 1968–2015*. Quezon City: National Water Resources Board.

Oorthuizen, J. (2003). *Water, works and wages*. Wageningen University Water Resources Series 3. New Delhi: Orient Longman Private Limited.

Panella, T. (2004). Irrigation development and management. In P. P. Molinga & A. Bolding (Eds.), *The politics of irrigation reform* (pp. 95–144). Cornwall, Great Britain: Ashgate.

Philippine Crop Insurance Corporation. (2016). *Data on insurance claims for palay, 1981-2015*. Quezon City: Philippine Crop Insurance Corporation.

Repetto, R. (1986). World enough and time: Successful strategies for resource management. Washington, D. C.: World Resources Institute.

Rola, A. C. (2015). *Characterizing the governance structure of the irrigation sector in the Philippines: National, regional and irrigation management office level analysis*. Makati, Philippines: Philippine Institute for Development Studies (PIDS).

Rola, A.C. & H.A. Francisco. (2004). Toward a win-win water management approach in the Philippines. Chapter 1. In A. C. Rola, H. A. Francisco, and J. P.T. Liguton (Eds.), *Winning the water war: Watersheds, water policies and water institutions*. Manila: Philippine Institute for Development Studies (PIDS) and Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD).

Rola, A., Francisco, H. A., & Liguton, J. P. T. (Eds.). (2004). *Winning the water war: Watersheds, water policies and water institutions*. Manila: Philippine Institute for Development Studies (PIDS) and Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD).

Shah, T. (2009). *Taming the anarchy: Groundwater governance in South Asia*. Washington D.C. and Colombo, Sri Lanka: Resources for the Future and International Water Management Institute (IWMI).

Shah, T., Burke, J., Villholth, K., Angelica, M., Custodio, E.,; Daibes, F., . . . Wang, J. (2007). Groundwater: A global assessment of scale and significance. In D. Molden (Ed.). *Water for food, water for life: A comprehensive assessment of water management in agriculture* (pp.395–423). London, UK and Colombo, Shri Lanka: Earthscan and International Water Management Institute (IWMI).

Shepley, S., Buenaventura, E., & Roco, D. (2000). *Technical assistance (TA) 3235 review of cost recovery mechanisms for National Irrigation Systems: Final Report to NIA and Asian Development Bank by Symonds Group, Ltd. with the Engineering and Development Corporation of the Philippines (EDCOP)*. Quezon City: National Irrigation Administration.

Tabios, G., & David, C. (2014). *Appraisal of methodology in estimating irrigable areas and processes of evaluating feasibility of NIA irrigation projects* (PIDS Policy Notes No. 2014-13). Makati City: Philippine Institute for Development Studies.

Zimmer, D., & Renault, D. (2003). *Virtual water in food production and global trade: Review of methodological issues and preliminary results*. In A.Y. Hoekstra (Ed.). Virtual water trade: Proceedings of the international expert meeting. (Value of Water Research Report Series No. 12). Netherlands: IHE Delft.