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Assessing the Philippine irrigation development program

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Irrigation systems were established in different parts of the Philippines to raise land productivity by providing sufficient water for agricultural activities. In the Pampanga River Basin alone, five major national irrigation systems (NIS) are operating, two of which are the Angat-Maasim River Irrigation System (AMRIS) and the Pampanga Delta River Irrigation System (PADRIS). These systems were originally constructed with design service areas of 31,400 and 11,540 hectares, respectively. However, AMRIS, completed in 1970s, only has actual irrigated area of 24,000 hectares during the dry season and 17,500 hectares during the wet season. Meanwhile, PADRIS, completed in 2002, only has actual irrigated area of 6,900 hectares during the dry season and 5,900 hectares during the wet season. While physical features, such as geology and topography, may have led to overestimation of design service areas, other factors, such as water availability and land use change, may have also caused their actual irrigated areas to be below their design irrigation areas.

This *Policy Note* assesses the water resources component of the resurgent Irrigation Development Program of the Philippines. It zeroes in on AMRIS and PADRIS and evaluates the ability of their water resources, land resources, and irrigation facilities to irrigate their designed area through watershed and irrigation modeling and simulation.

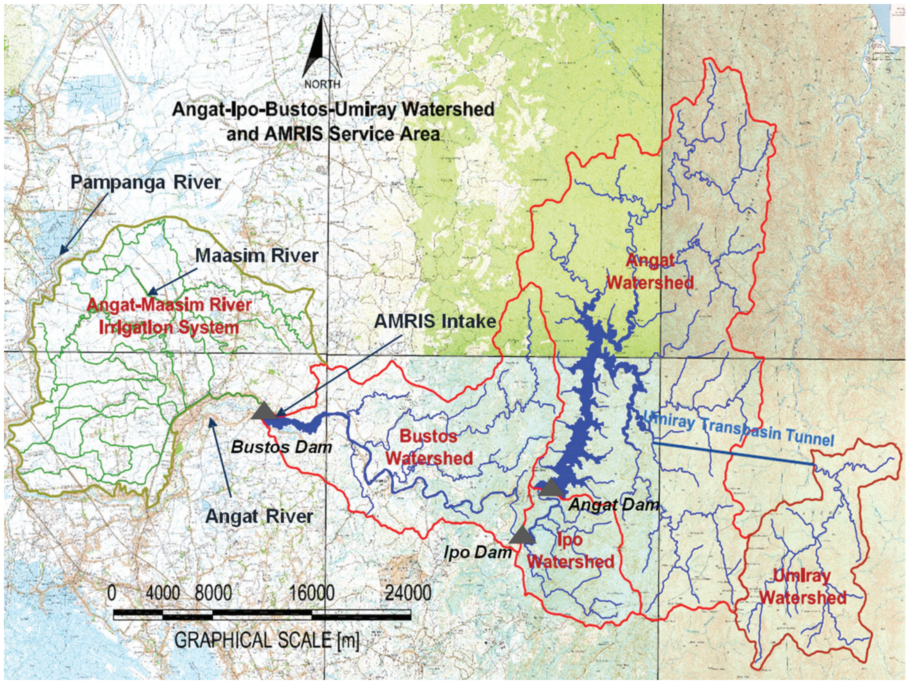
The Angat-Maasim River Irrigation System

The irrigation water supply of AMRIS comes mainly from the Angat Reservoir, whose inflows come from Angat watershed and Umiray River through the Umiray transbasin tunnel (Figure 1). Its additional water source is the local inflow from Bustos watershed. However, Angat Reservoir through Ipo Dam (with local inflow from Ipo watershed) also provides water supply to Metro Manila, thus competing with the irrigation needs of AMRIS (Tabios 2016).

According to the National Irrigation Administration (NIA) (n.d.), the irrigated area of AMRIS has been declining in the last decade, from 22,000 hectares down to 17,500 hectares during the wet season and from 27,500 hectares to 24,000 hectares during the dry season. Its original design service area of 31,400 hectares was never attained.

With these historical irrigated areas, a simple water balance computation for AMRIS planted with paddy rice

Figure 1. Angat Reservoir water resource system including the Angat-Maasim River Irrigation System



AMRIS = Angat-Massim River Irrigation System
Source: Tabios and David (2014)

can be computed. As shown in Tabios and David (2014), the average daily paddy rice water requirement of AMRIS was 1.12 liters/second/hectare for the case without wasted water and 1.67 liters/second/hectare for the case with wasted water. During the four-month cropping season, the irrigation water requirement ranged from 19.6 to 29.2 cubic meter/second during the wet season for the 17,500 hectares and from 26.88 to 40.1 cubic meter/second during the dry season for 24,000 hectares.

Table 1 shows the historical releases of Angat Reservoir and the National Water Resources Board (NWRB) to AMRIS and the Metropolitan Waterworks and Sewerage System (MWSS). The average annual historical releases of Angat Reservoir to AMRIS is 27.46 cubic meter/second, the midpoint of paddy rice water requirement of 19.6 cubic meter/second (minimum of case without wasted water) and 40.1 cubic meter/second (maximum of case with wasted water).

The study also analyzed the historical daily flows of Angat Reservoir, Ipo Dam, Bustos Dam, and Umiray River flows to Angat using the Sacramento-based watershed model (Table 2). It found that the range of dependable Bustos Dam local inflow at 80 percent (about 290 days a year) and 60 percent (about 220 days a year) was 2.97 and 8.66 cubic meter/second, respectively, which covered the deficit of 6 cubic meter/second mentioned above. Meanwhile, it found that the NWRB allocation, at an average daily flow of 24.21 cubic meter/second, was adequate for AMRIS although the NWRB allocation for MWSS was 46 cubic meter/second. Nonetheless, the actual historical releases from Angat Reservoir to AMRIS is 27.46 cubic meter/second while only 36.28 cubic meter/second to MWSS. Still, the latter may be augmented by Ipo Dam local inflow, which has a daily average of 8.72 cubic meter/second.

The big question remains as to the failure of AMRIS to attain its design irrigated area of 31,400 hectares. As found by Tabios and David (2014), only 24,000 hectares has been irrigated by AMRIS during the dry season. The remaining portion is either above the 20-meter elevation (3,000 hectares) or already urbanized (5,000 hectares).

Table 1. Averages of releases to MWSS and AMRIS from Angat Reservoir calculated from daily data (1996-2013) including NWRB allocation for AMRIS (in cubic meter/second)

Month	Historical Releases to MWSS	Historical Releases to AMRIS	NWRB Allocation for AMRIS
January	37.97	38.50	36.00
February	39.30	35.80	39.86
March	38.74	27.94	31.00
April	40.01	14.12	15.50
May	41.09	7.94	0.00
June	43.88	15.58	27.90
July	33.17	20.97	28.00
August	29.01	21.51	25.00
September	29.99	24.87	22.73
October	34.21	28.56	13.00
November	32.82	39.80	17.57
December	35.19	53.88	34.00
Annual Average	36.28	27.46	24.21

MWSS = Metropolitan Waterworks and Sewerage System; AMRIS = Angat-Massim River Irrigation System; NWRB = National Water Resources Board
Source: Tabios (2017)

Table 2. Flow duration analysis of the sources of water of Angat-Maasim River Irrigation System (in cubic meter/second)

	Angat Reservoir Inflows			Ipo Dam Local Inflows	Bustos Dam Local Inflows	Umiray River Flow to Angat Reservoir
	Historical Data (1996-2012)	Model Computed (1996-2012)	Model Computed (1974-2013)			
Average	63.01	63.30	65.98	8.72	28.18	15.02
Minimum	0.00	1.68	0.71	0.09	0.31	0.16
Maximum	1526	2309	2988	398	1278	684
Q90 percent	4.64	4.78	3.56	0.47	1.52	0.80
Q80 percent	12.68	8.79	6.97	0.91	2.97	1.58
Q60 percent	27.99	23.25	20.33	2.66	8.66	4.59
Q40 percent	46.50	47.11	45.80	6.02	19.53	10.40
Q20 percent	80.11	89.94	91.91	12.23	39.66	21.08

Q = flow discharge that can be equal or greater than that amount that can be observed within a specific time frame. For instance, Q90 refers to that flow dischange within 90 percent of a year, or about 328 days, on the average.
Source: Tabios (2017)

Meanwhile, the irrigated area usually shrinks to 17,500 hectares during the wet season, as the flooding renders the additional 5,500 hectares unsuitable for planting.

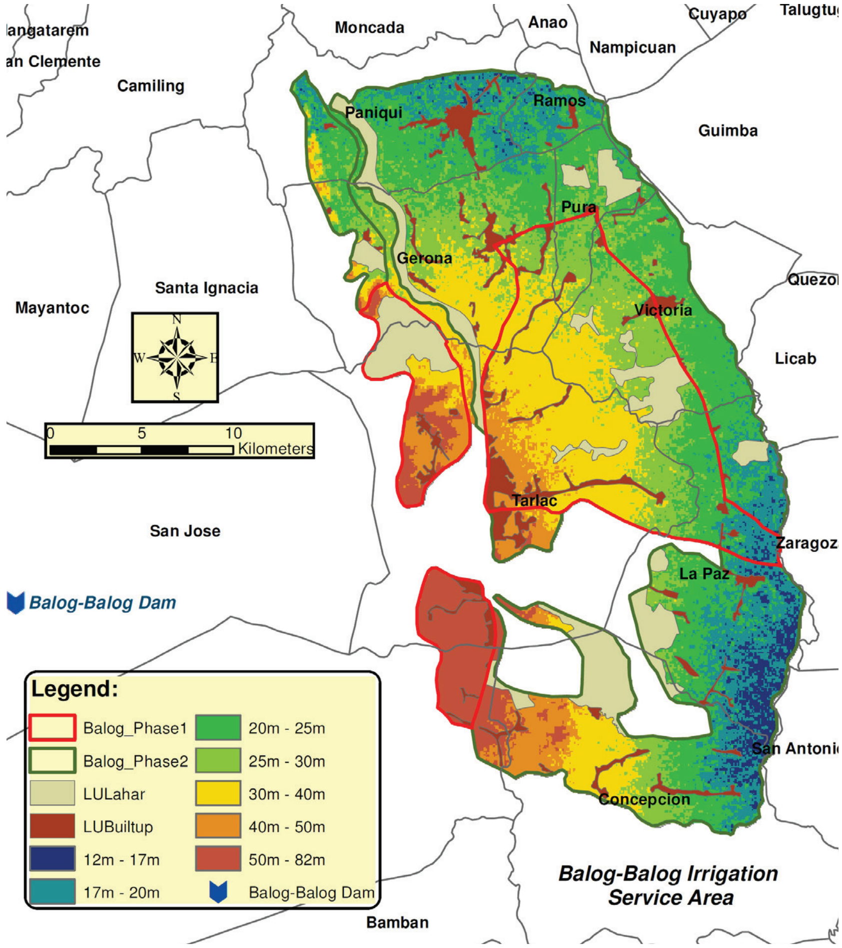
The Pampanga Delta River Irrigation System

Completed in 2002, PADRIS has a design service area of 11,540 hectares. Its water source is the Pampanga River diverted through the Cong Dadong Dam diversion structure (Figure 2).

For the design service area of 11,540 hectares, the irrigation water supply of PADRIS from the Pampanga River at 108 cubic meter/second with 80-percent dependable flow is fairly adequate. Note that its average daily water requirement is 19.3 cubic meter/second for the design service area of 11,540 hectares.

According to NIA (personal communication, December 4, 2018), the historical irrigated service areas of PADRIS

Figure 2. Pampanga Delta Irrigation System including its physical features



Source: Tabios and David (2014)

from 2003 to 2014 during the wet season was 5,900 hectares, or barely 35 percent of its design service area of 11,540 hectares. Meanwhile, its maximum irrigated area during dry season was at 6,900 hectares, or 60 percent of its design area.

Based on the map of PADRIS, around 1,050 hectares of its areas are urbanized while 1,650 hectares are with fish ponds. Meanwhile, around 2,000 hectares were with elevation of at least 8.5 meter, thus above intake level at Cong Dadong Dam. On the other hand, its flood prone areas during the wet season were about 950 hectares. As such, only 6,840 hectares out of 11,540 hectares can be irrigated during the dry season. During the wet season, the irrigated area further dwindles to 5,890 hectares due to flooding.

The performance of canal network

As there was difficulty obtaining data for PADRIS, only the North Main Canal of AMRIS was subjected to hydraulic simulation. Its irrigation service area is about 12,200 hectares, about half of the irrigated area covered during the dry season.

Using the unsteady flow model (USACE 1995), the study found that the water depths in the main canal relative to the laterals were relatively low, thus pumping is required to transfer water from main canal to lateral canal. The inflow of 26.65 cubic meter/second is required to sufficiently and uniformly irrigate the service area. However, this water requirement is at 2.2 liter/second/hectare, which is quite wasteful and excessive. The reason why not all areas can be sufficiently and

Urbanization is perceived as one of the key issues behind the reduction of service areas of river irrigation systems in the Philippines. In the Pampanga River Basin alone, a significant portion of the agricultural land was already converted to industrial or residential developments. Photo: National Irrigation Administration/Facebook

uniformly irrigated can be attributed to several factors. The major reason is that certain channel sections have become shallow due to sedimentation. This resulted in a channel network with no longer proper channel gradients or slopes to deliver water over the entire area. This inability to efficiently move water consequently leads to difficulty in proper allocation and uniform water delivery to the target irrigation service areas.

Ways forward

Both AMRIS and PADRIS have reduced irrigation service area compared with the original design service area due to urbanization and flooding problems, as well as technical issues. In the case of urbanization in the AMRIS area, a significant portion of the agricultural land was already converted to industrial or residential developments. Urbanization has also taken its toll on agricultural areas in PADRIS, being adjacent to the growing metropolis development of New Clark City and San Fernando City in Pampanga. With regard to flooding problems, both AMRIS and PADRIS have low lying areas in their lower ends. Being in the vicinity of the Pampanga Delta, there is not much can be done to encourage the rice farmers to plant rice during the wet season.

Nonetheless, the government may still adopt the following recommendations to minimize the problems faced by both AMRIS and PADRIS.

Revisit cropping schedules

The irrigation water supply to AMRIS from Angat Reservoir (including contribution from Bustos watershed) may be curtailed due to episodic occurrences of critical dry seasons associated to Pacific Equatorial anomalies such as El Niño. It can also be constrained due to competing water uses with domestic water supply, which has higher release policy during low Angat Reservoir water levels or water shortage conditions.

Although the AMRIS irrigation water demand has reduced in the last 20 years, the irrigation water requirement of AMRIS is still significant especially during the dry cropping season period of December to March, which coincides with the onset of the dry season when the Angat Reservoir should be filling-up or saving water in preparation for the dry months of April and May. Thus, the dry and wet cropping season schedules should be revisited to maximize AMRIS's conjunctive use of Angat watershed streamflow and minimize its competing use with Metro Manila's water supply demand.

Increase height of diversion structure

Water supply to PADRIS is not at all limiting since there is more than enough flowing from the Pampanga River at the point of diversion. The only constraint is that the diversion dam elevation is not high enough to cover the entire design service area of PADRIS. As such, over 2,000 hectares cannot be irrigated. It is thus recommended to increase the height of the diversion structure of PADRIS and the economics of this should be carefully considered.

Mitigate sedimentation

In AMRIS, the canal network simulation studies of irrigation water flows show that there are areas not irrigated due to canal shallowing as a result of sedimentation. Consequently, the channel slopes needed for gravity flow are no longer efficient. The government should thus properly mitigate the sedimentation problem and design the canal maintenance with dredging or rehabilitation to optimally satisfy both the slope and canal width and depth, including alignment requirements. This type of analysis and operations studies can only be done through canal network model simulation studies.

Conduct periodic operational studies

Finally, periodic operational studies once the system is already built are crucial to adjust based on actual observations and experiences. Likewise, periodic assessment of the efficiency of irrigation water delivery operations should be conducted for proper maintenance and upgrade of irrigation facility, if needed.

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